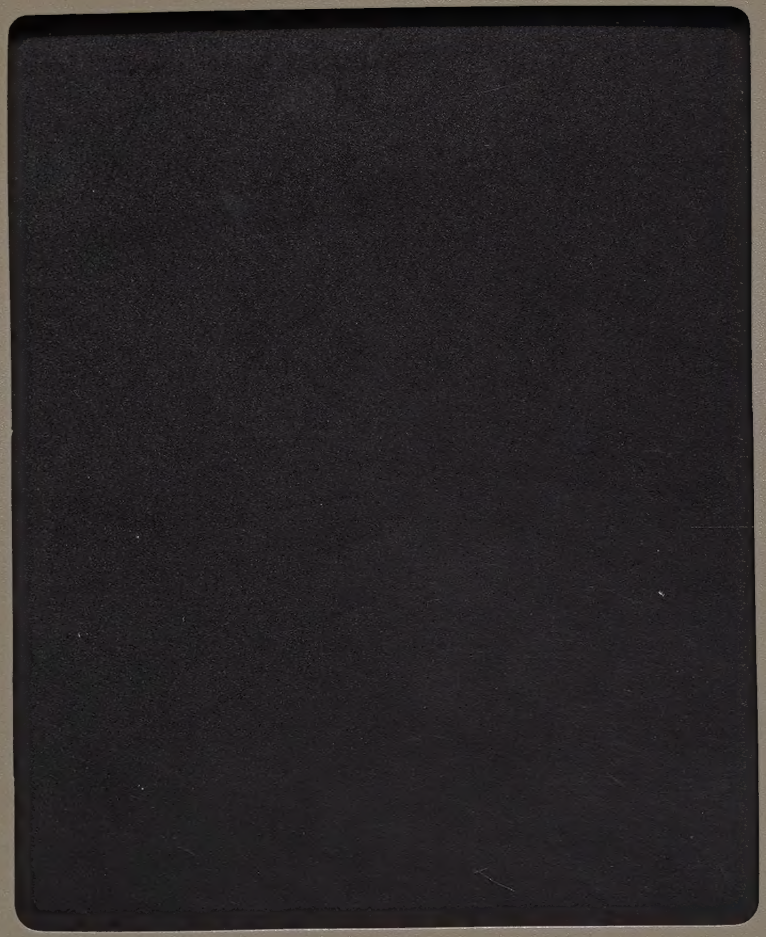
FLUKE®



NOTE

This manual documents the Model 7220A and its assemblies at the revision levels shown in Appendix 7A. If your instrument contains assemblies with different revision letters, it will be necessary for you to either update or backdate this manual. Refer to the supplemental change/errata sheet for newer assemblies, or to the backdating sheet in Appendix 7A for older assemblies.

7220A

Frequency Counter

Instruction Manual

P/N 487488
August 1980
Rev. 1 10/80
Rev. 2 11/80

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FLUKE®

WARRANTY

Notwithstanding any provision of any agreement the following warranty is exclusive:

The JOHN FLUKE MFG. CO., INC., warrants each instrument it manufactures to be free from defects in material and workmanship under normal use and service for the period of 1-year from date of purchase. This warranty extends only to the original purchaser. This warranty shall not apply to fuses, disposable batteries (rechargeable type batteries are warranted for 90-days), or any product or parts which have been subject to misuse, neglect, accident, or abnormal conditions of operations.

In the event of failure of a product covered by this warranty, John Fluke Mfg. Co., Inc., will repair and calibrate an instrument returned to an authorized Service Facility within 1 year of the original purchase; provided the warrantor's examination discloses to its satisfaction that the product was defective. The warrantor may, at its option, replace the product in lieu of repair. With regard to any instrument returned within 1 year of the original purchase, said repairs or replacement will be made without charge. If the failure has been caused by misuse, neglect, accident, or abnormal conditions of operations, repairs will be billed at a nominal cost. In such case, an estimate will be submitted before work is started, if requested.

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OF MERCHANTABILITY, FITNESS, OR ADEQUACY FOR ANY PARTICULAR PURPOSE OR USE. JOHN FLUKE MFG. CO., INC., SHALL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES, WHETHER IN CONTRACT, TORT, OR OTHERWISE.

If any failure occurs, the following steps should be taken:

1. Notify the JOHN FLUKE MFG. CO., INC., or nearest Service facility, giving full details of the difficulty, and include the model number, type number, and serial number. On receipt of this information, service data, or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, transportation prepaid. Repairs will be made at the Service Facility and the instrument returned, transportation prepaid.

SHIPPING TO MANUFACTURER FOR REPAIR OR ADJUSTMENT

All shipments of JOHN FLUKE MFG. CO., INC., instruments should be made via United Parcel Service or "Best Way"* prepaid. The instrument should be shipped in the original packing carton; or if it is not available, use any suitable container that is rigid and of adequate size. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

CLAIM FOR DAMAGE IN SHIPMENT TO ORIGINAL PURCHASER

The instrument should be thoroughly inspected immediately upon original delivery to purchaser. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument is damaged in any way, a claim should be filed with the carrier immediately. (To obtain a quotation to repair shipment damage, contact the nearest Fluke Technical Center.) Final claim and negotiations with the carrier must be completed by the customer.

The JOHN FLUKE MFG. CO., INC, will be happy to answer all applications or use questions, which will enhance your use of this instrument. Please address your requests or correspondence to: JOHN FLUKE MFG. CO., INC., P.O. BOX C9090, EVERETT, WASHINGTON 98206, ATTN: Sales Dept. For European Customers: Fluke (Holland) B.V., P.O. Box 5053, 5004 EB, Tilburg, The Netherlands.

*For European customers, Air Freight prepaid.

John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, Washington 98206

Rev. 6/81

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7220A Frequency Counter

Section 1
Introduction & Specifications

1-1. INTRODUCTION

1-2. The John Fluke Model 7220A is a nine-digit portable, bench-type Counter that provides wide-range frequency measurement capability up to 1300 MHz. There are two input channels. The ac-coupled Channel A input allows frequency measurements from 10 Hz to 125 MHz with 1 Megohm input impedance. The Channel B input allows prescaled frequency measurements of continuous wave or burst signals from 100 MHz to 1300 MHz with 50 ohm input impedance. Channel A signal conditioning includes a X10 fixed attenuator and a X10 variable attenuator. For low frequency measurements, a 100 kHz low-pass filter may be selected. Four standard resolution settings and gate times may be selected that allow resolution in decade steps from 100 Hz to 0.1 Hz. Four additional resolution settings (up to .0001 Hz) are available when the Resolution Multiplier Option -351 is installed.

1-3. Measurements are displayed on a nine-digit LED display. Three LED annunciators indicate gate time, measurement overflow, and if optional oven time base is receiving power. The 7220A may be operated with the standard 10 MHz time base, an optional TCXO (Temperature Compensated Crystal Oscillator) time base, or either of two optional low power oven time bases. A self check mode applies the time base signal to the internal counters, thus providing a check for most of the 7220A internal circuitry.

1-4. The 7220A is enclosed in a PTI (Portable Test Instrument) case which includes an inner metal lining for RFI shielding. The counter may be operated at switch selectable line voltages of 100V, 120V, 220V or 240V at 47-63 Hz, or with an optional battery pack.

1-5. OPTIONS AND ACCESSORIES

1-6. When the Battery Pack Option -010 is installed along with one of the optional oven time bases, high measurement accuracy is provided with portable convenience. When the Digital Interface Option -521 is installed in the 7220A, serial BCD data is available at a rear panel output. Option -521 also allows the counter to operate directly into a Fluke 2020A, 2021A, or 2030A Printer (with Option -004 installed in the Printer). When Option -521 is installed in the 7220A, and it is used with a Fluke 1120A Translator with Option -522 installed (in the 1120A), the 7220A is compatible with the IEEE-488 Bus. All of the options are described in detail in Section 6. Tables 1-1 and 1-2 list the available options and accessories for the 7220A.

1-7. SPECIFICATIONS

1-8. Specifications for the 7220A are given in Table 1-3. Comparative specifications for all of the optional time bases are also given. Specifications for the options are included in Section 6 with the option descriptions.

Table 1-1. 7220A Options

OPTION NO.	DESCRIPTION
72XXA-010	Battery Pack
7220A-111	1 PPM TCXO Time Base
72XXA-131	Low Power Oven Time Base
72XXA-132	Superior Low Power Oven Time Base
7220A-351	Resolution Multiplier
72XXA-521	Digital Interface (factory-installed in 7220A)
72XXA-522	Interface PCB Assy (installed in 1120A)
72XXA-529	IEEE-488 Interface (includes Options -521, -522, and Accessory Cable Y7203)

Table 1-2. 7220A Accessories

ACCESSORY NO.	DESCRIPTION	ACCESSORY NO.	DESCRIPTION
A53	Whip Antenna	Y2020	C-Size Panel Adapter
Y2014	C-Size Single Rack Adapter	Y7203	2-Foot Ribbon Cable Assembly
Y2015	C-Size Dual Rack Adapter	Y7204	5-Foot Ribbon Cable Assembly

Table 1-3. Specifications

FUNCTIONS

Frequency A
- Range . . . . . 10 Hz – 125 MHz
- Resolution . . . . . 0.1 Hz, 1 Hz, 10 Hz, 100 Hz
- Accuracy . . . . . ±1 count ± time base errors
- Display . . . . . MHz with decimal point
- Measurement Time . . . . . Gate Time* + cycle time**

Frequency B
- Range . . . . . 100 MHz – 1300 MHz
- Resolution . . . . . 0.1 Hz, 1 Hz, 10 Hz, 100 Hz
- Accuracy . . . . . ±1 count ± time base errors
- Display . . . . . MHz with decimal point
- Measurement Time . . . . . Gate time* + cycle time**
- Burst Mode
  - Minimum Burst. . . . . Gate Time* + 40 ms
  - Automatic Hold . . . . . Display holds last complete reading until Reset

**For gate times, see Table 2-5.*
***Cycle time is approximately 150 ms.*

SIGNAL INPUT – CHANNEL A

- Bandwidth . . . . . 10 Hz – 125 MHz, ac coupled
- Sensitivity . . . . . 10 mV rms at 10 Hz – 50 MHz
  15 mV rms at 50 MHz – 100 MHz
  25 mV rms at 100 MHz – 125 MHz
- Input Impedance. . . . . 1 Megohm, shunted by 60 pF
- Attenuator. . . . . X1 to X100, X1 or X10 fixed plus
  X1 to X10 continuously variable
- Filter . . . . . 100 kHz low pass selectable
- Maximum Input Voltage. . . . . See chart below:

Channel A Maximum Input Voltage

Table 1-3. Specifications (cont)

SIGNAL INPUT – CHANNEL B

Bandwidth	100 MHz – 1300 MHz
Sensitivity	5 mV rms at 100 MHz to 600 MHz 10 mV rms at 600 MHz to 1000 MHz 40 mV rms at 1000 MHz to 1300 MHz
Input Impedance	50 ohm
VSWR	2.5:1 typical maximum
Maximum Input Voltage	5V rms at 100 MHz to 1300 MHz

SIGNAL INPUT – EXTERNAL TIME BASE

Frequency Required	10 MHz
Sensitivity	300 mV rms
Input Impedance	1 kilohm, shunted by nominal 30 pF, ac coupled
Maximum Input Voltage	3V rms

SIGNAL OUTPUT – TIME BASE

Frequency	10 MHz, square wave
Amplitude	TTL levels
Impedance	200 ohms, nominal

STANDARD TIME BASE

Frequency	10 MHz
Aging Rate per month	$\pm 5 \times 10^{-7}$
Temperature Stability	$\pm 5 \times 10^{-6}$, 0 to 40°C
Line Voltage (± 10% change)	$\pm 1 \times 10^{-7}$
Battery Operation	$\pm 1 \times 10^{-7}$

OPTIONAL TIME BASES

	OPTION -111 1 PPM TCXO	OPTION -131 Low Power Oven	OPTION -132 Superior Low Power Oven
Frequency	10 MHz	10 MHz	10 MHz
Aging Rate			
Per day	–	–	$\pm 3 \times 10^{-9}$*
Per month	$\pm 3 \times 10^{-7}$	$\pm 1 \times 10^{-7}$*	$\pm 5 \times 10^{-8}$*
Per year	$\pm 1 \times 10^{-6}$	–	–
Accuracy with temperature** (0° to 40°C)	$\pm 1 \times 10^{-6}$	$\pm 1 \times 10^{-7}$	$\pm 3 \times 10^{-8}$
Line Voltage	$\pm 2 \times 10^{-7}$	$\pm 2 \times 10^{-8}$	$\pm 4 \times 10^{-9}$
Battery Operation	$\pm 2 \times 10^{-7}$	$\pm 5 \times 10^{-8}$	$\pm 1 \times 10^{-8}$
Warm up***			
10 Min	–	$\pm 5 \times 10^{-7}$	$\pm 5 \times 10^{-7}$
20 Min	–	$\pm 3 \times 10^{-8}$	$\pm 3 \times 10^{-8}$

**After 5 days continuous operation.*

***Includes errors caused by temperature variations during operation as well as all calibration errors when calibrated per specifications.*

****Compared to frequency 24 hours after turn-on.*

Table 1-3. Specifications (cont)

GENERAL

Display Annunciation	9-digit LED, with leading zero suppression and decimal point. Three LED annunciators: Gate, Measurement Overflow, Oven Time Base Power.
Cycle Rate	In continuous measurement mode, time between end of one gate time and beginning of next gate time is fixed at approximately 150 ms.
Self Check	Counts and displays 10 MHz Time Base.
Reset	Reset switch clears display; holding Reset lights all 9-digit LED segments, releasing Reset allows new measurement to take place.
Power Requirements	24 VA maximum
Line Voltage	100V, 120V, 220V or 240V ac ± 10%, internally selectable
Line Frequency	47–63 Hz
Dimensions	40.3 cm L x 20.3 cm W x 10.8 cm H (12.9 in L x 8.0 in W x 4.3 in H) See Figure 1-1.
Operating Temperature	0° to 40°C
Storage Temperature	-40° to 70°C
Weight	3.2 kg (7 lbs)
EMI	Internal metal RFI shield meets most requirements of MIL-STD-461, notice 3.
Protection Class 1	Relates solely to insulation or grounding properties defined in IEC 348.

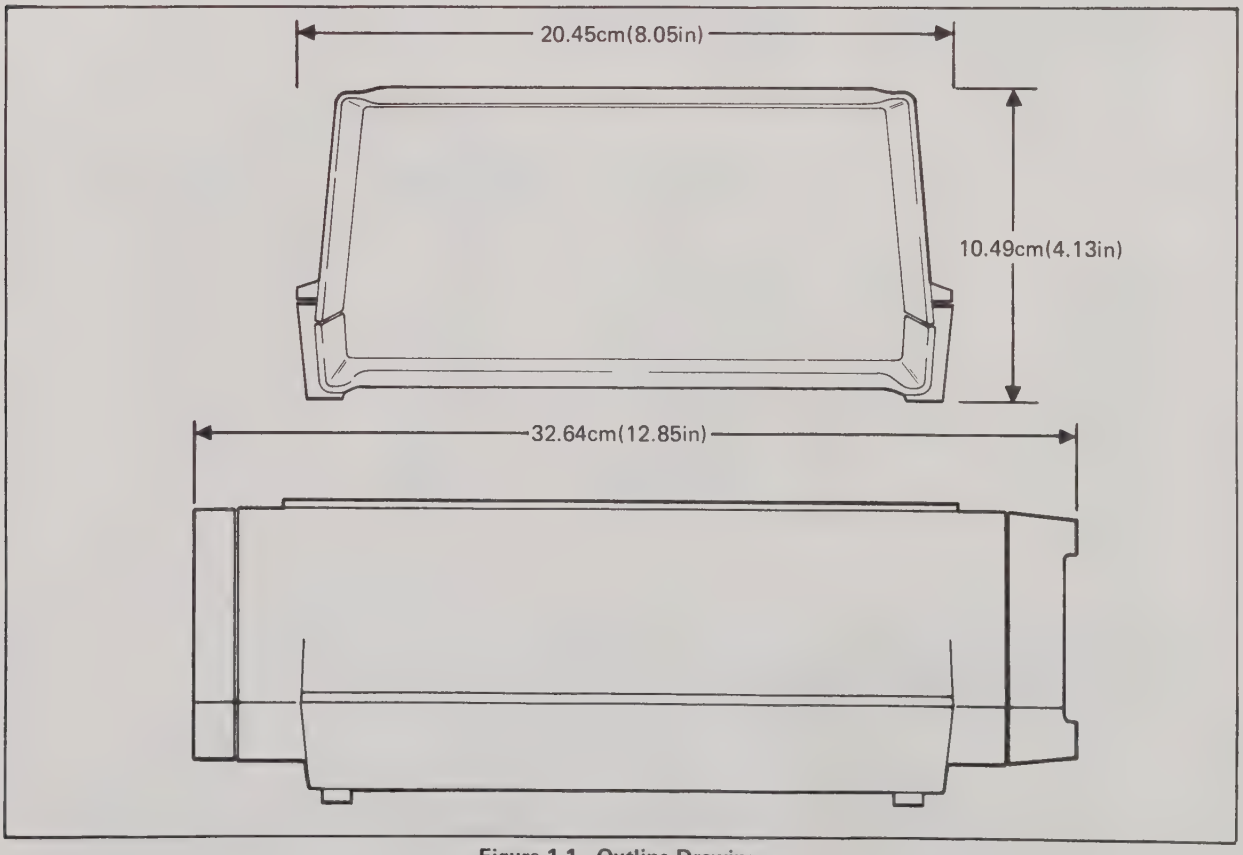
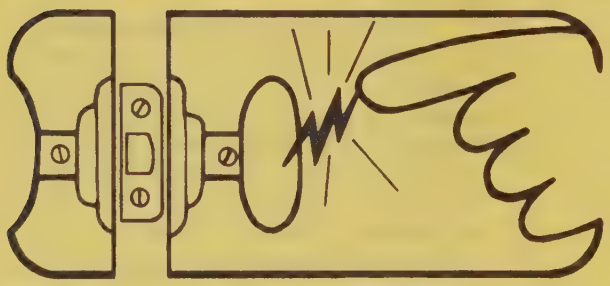


Figure 1-1. Outline Drawing

static awareness

A Message From

John Fluke Mfg. Co., Inc.

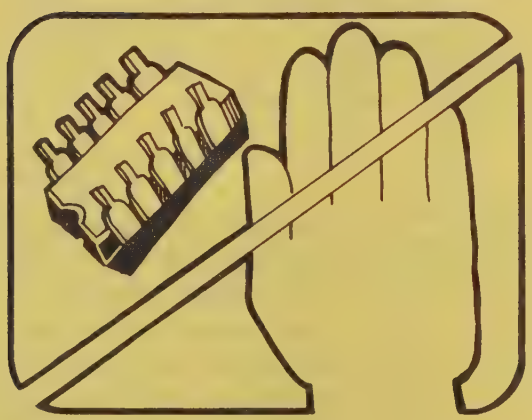


Some semiconductors and custom IC's can be damaged by electrostatic discharge during handling. This notice explains how you can minimize the chances of destroying such devices by:

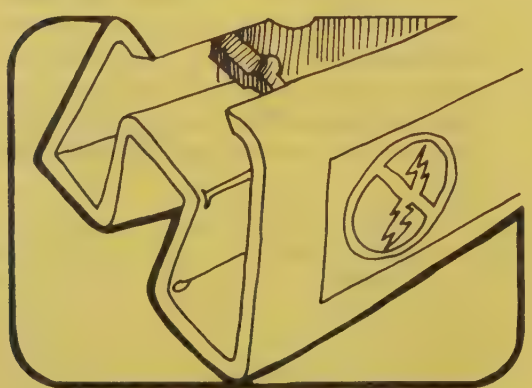
1. Knowing that there is a problem.
2. Learning the guidelines for handling them.
3. Using the procedures, and packaging and bench techniques that are recommended.

The Static Sensitive (S.S.) devices are identified in the Fluke technical manual parts list with the symbol "⊗"

The following practices should be followed to minimize damage to S.S. devices.

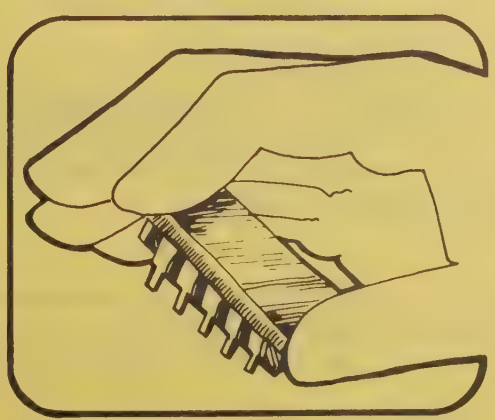


1. MINIMIZE HANDLING

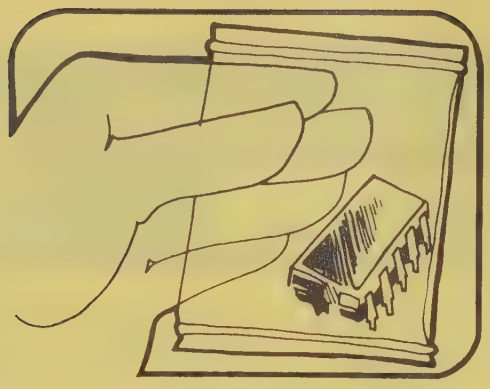


2. KEEP PARTS IN ORIGINAL CONTAINERS UNTIL READY FOR USE.

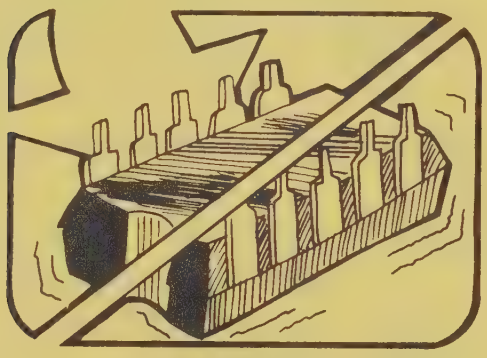
3. DISCHARGE PERSONAL STATIC BEFORE HANDLING DEVICES



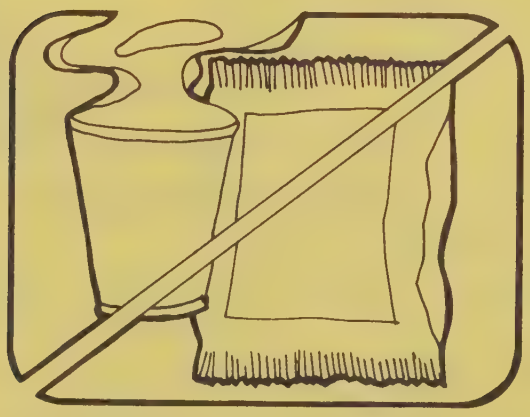
4. HANDLE S.S. DEVICES BY THE BODY



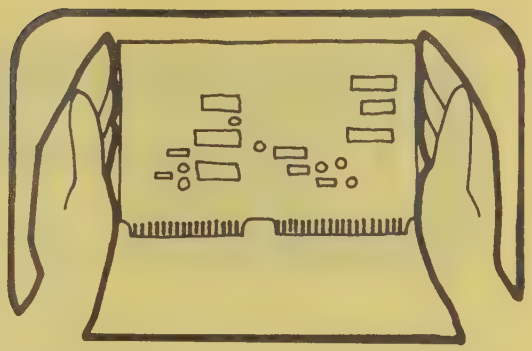
5. USE ANTI-STATIC CONTAINERS FOR HANDLING AND TRANSPORT



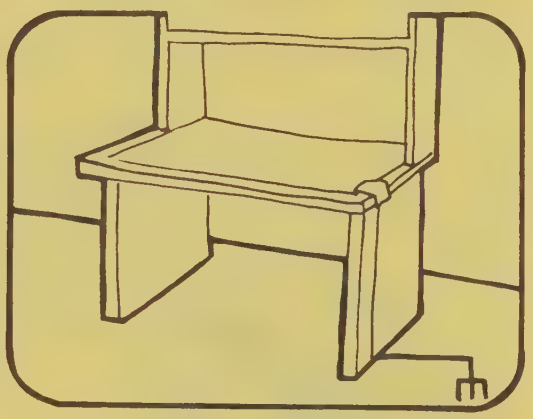
6. DO NOT SLIDE S.S. DEVICES OVER ANY SURFACE



7. AVOID PLASTIC, VINYL AND STYROFOAM® IN WORK AREA



8. WHEN REMOVING PLUG-IN ASSEMBLIES, HANDLE ONLY BY NON-CONDUCTIVE EDGES AND NEVER TOUCH OPEN EDGE CONNECTOR EXCEPT AT STATIC-FREE WORK STATION. PLACING SHORTING STRIPS ON EDGE CONNECTOR USUALLY PROVIDES COMPLETE PROTECTION TO INSTALLED SS DEVICES.



9. HANDLE S.S. DEVICES ONLY AT A STATIC-FREE WORK STATION
10. ONLY ANTI-STATIC TYPE SOLDER-SUCKERS SHOULD BE USED.
11. ONLY GROUNDED TIP SOLDERING IRONS SHOULD BE USED.

Anti-static bags, for storing S.S. devices or pcbs with these devices on them, can be ordered from the John Fluke Mfg. Co., Inc.. See section 5 in any Fluke technical manual for ordering instructions. Use the following part numbers when ordering these special bags.

John Fluke Part No.	Description
453522	6" X 8" Bag
453530	8" X 12" Bag
453548	16" X 24" Bag
454025	12" X 15" Bag
Pink Poly Sheet 30"x60"x60 Mil P/N RC-AS-1200 $20.00	Wrist Strap P/N TL6-60 $7.00

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Section 2
Operating Instructions

2-1. INTRODUCTION

2-2. This section of the manual contains information concerning the installation and operation of the Model 7220A Frequency Counter. The contents of this section should be read before operating the counter. Should any difficulties arise during operation of the instrument, please contact your nearest John Fluke Sales Representative, or the John Fluke Mfg. Co., Inc. (P.O. Box 43210, Mountlake Terrace, WA., 98043; Telephone 206 774-2211). A list of sales representatives is given in Section 7.

2-3. SHIPPING INFORMATION

2-4. The 7220A is packaged and shipped in a foam-packed container. Upon receipt of the instrument, make a thorough inspection for proper contents and possible shipping damage. Special instructions for inspection and claims are included with the shipping container. If reshipment is necessary, use the original container. If the original container is not available, a new container can be obtained from the John Fluke Mfg. Co., Inc. Please specify the instrument model number when requesting a new shipping container.

2-5. INSTALLATION

2-6. Input Power

2-7. The 7220A can be operated with an input line voltage of 100, 120, 220, or 240V ac (±10%). Line frequency may vary between 47 and 63 Hz. A rear panel decal specifies the voltage selected prior to shipment. If a change in voltage is required, have a qualified technician perform the procedure. The selection procedure is given in Section 4 of this manual. Replace the fuse when the line voltage setting is changed. Proper fuse ratings are given under Fuse Replacement.

2-8. Fuse Replacement

2-9. The ac input line and the Channel B input line are both fuse protected. The ac input line fuse (F1) is accessible by way of a rear panel fuse holder located to the right of the input power connector. If fuse replacement is required, disconnect the 7220A from line power and remove the fuse cap and fuse (twist the fuse cap ccw using a screwdriver). Select and install a replacement fuse with a rating that is compatible with the local line voltage. Replacement fuse information for the line power fuse is available on the rear panel decal and in the following list. Channel B fuse replacement requires removal of the instrument covers, and should only be performed by a qualified technician. The Channel B fuse replacement procedure is given in Section 4.

1. 100 to 120V ac use fuse type MDL slo-blo 1/4A

2. 220 to 240V ac use fuse type MDL slo-blo 1/8A

2-10. Stacking PTI Instruments

2-11. The stacking feature of the PTI case allows the 7220A to be stacked with, and locked to other Fluke instruments in the PTI product line. Use the following procedure to stack PTI instruments:

1. Locate and pull the black latches on both sides of the unit to their extended position.

2. Place the unit on top of the PTI stack with the front panel toward the front of the stack. See Figure 2-1.

3. When the unit is properly seated, push both latches in. This will lock the unit to the stack.

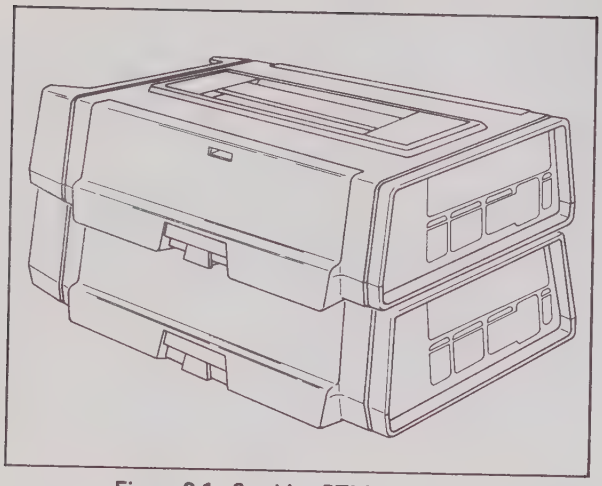


Figure 2-1. Stacking PTI Instruments

2-12. Tilt-Down Bail

2-13. When used as a separate instrument, the 7220A may be tilted up, or down, with the aid of the tilt bail. In the extended position, the bail may be locked in place by firmly pressing the legs into slots provided in the bottom panel. When retracted, the bail lies flush with the bottom panel and does not interfere with case stacking. The bail is normally mounted toward the front of the instrument. To remove the bail, compress either of its legs toward the center of the case and pull out. Installation may then be made in identical mounts at the rear of the bottom panel.

2-14. Rack Installation

2-15. The 7220A may be installed in a standard 19-inch equipment rack or a DIN panel mount. Mounting kits for these accessories are described in Section 6 of this manual. A list of all available accessories and options is presented in Section 1.

2-16. OPERATING FEATURES

2-17. The function and location of all 7220A controls, indicators, and connectors are shown in Figures 2-2 and 2-3, and described in Tables 2-1 and 2-2.

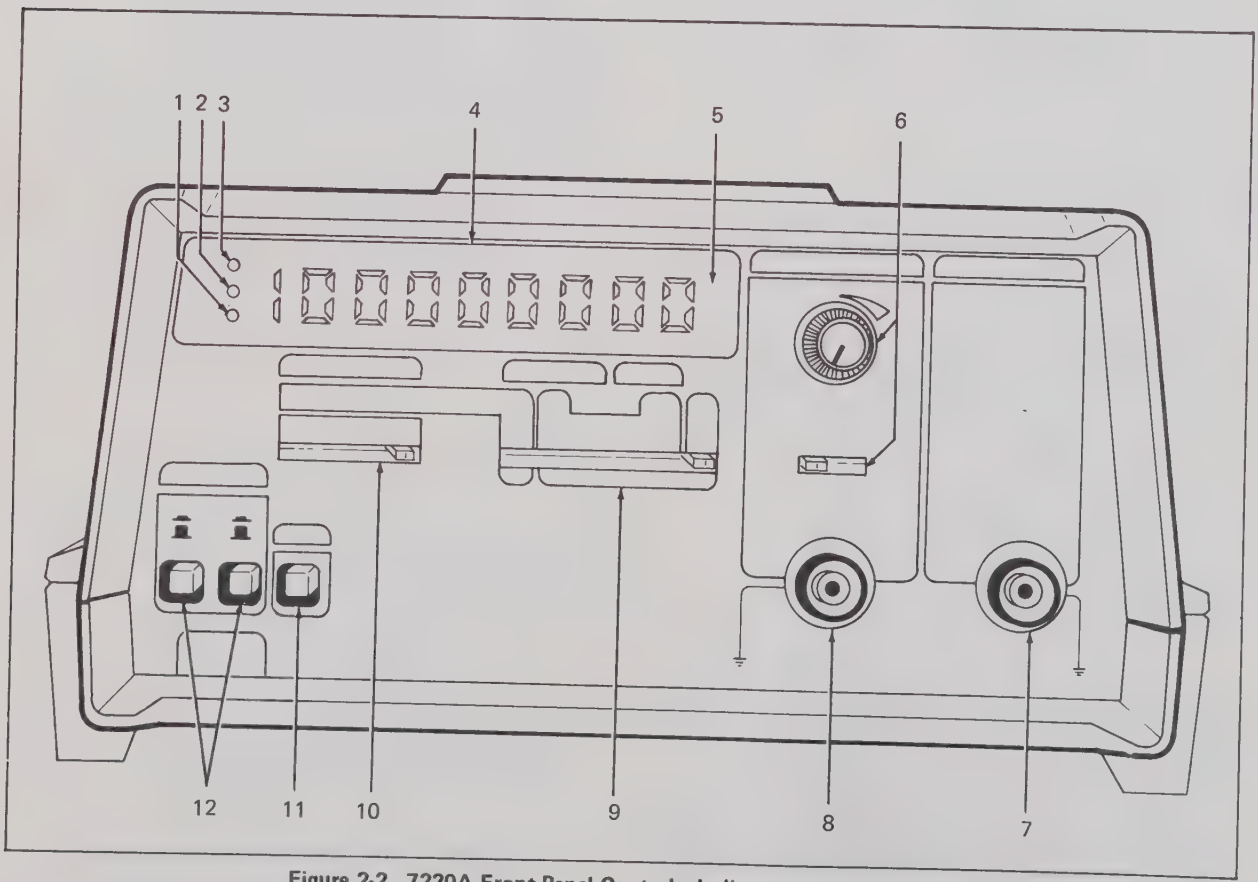


Figure 2-2. 7220A Front Panel Controls, Indicators and Connectors

Table 2-1. 7220A Front Panel Controls, Indicators, and Connectors

REF. NO.	NAME	FUNCTION
1	OVEN Annunciator	Illuminates if an oven time base is installed and is receiving power.
2	OVFL Annunciator	Illuminates if the accumulator has exceeded the measurement range selected.
3	GATE Annunciator	Illuminates while the Main Gate is enabled and the input frequency is being counted.
4	Display	A nine digit LED measurement display with automatic decimal point placement and leading zero suppression.
5	Measurement Units Indicator	Indicates the units for the measurement displayed. All measurements are displayed in MHz, except when the Resolution Multiplier Option is selected using the Function Control. Then the measurement is displayed in Hz.
6	ATTENUATION Controls	These two controls (which only affect Channel A) can be used to limit the input signal to the dynamic operating range of the input amplifier. The upper rotating control allows variable attenuation between X1 and X10. The lower two-position slide switch allows step attenuation of X10. The two controls can be used separately or together to allow total attenuation range of X1 to X100.
7	CHANNEL B Connector	BNC input connector for Channel B. Channel B has a 50 ohm input impedance and is internal fuse protected.
8	CHANNEL A Connector	BNC connector for Channel A. Channel A has a 1 megohm input impedance.
9	CH A/CH B	A six-position slide switch which allows selection of 7220A operating mode. Moving the slide between positions automatically generates a Reset command for the instrument. The function of each operating mode is as follows: CHK Initiates instrument self-test. The 10 MHz time base signal from the instrument is applied to the counting circuitry. This allows an internal check of all instrument circuits except the input circuits. In this mode, the frequency displayed should be 10 MHz. CH B 1300 Enables Channel B measurement of signals from 100 MHz to 1.3 GHz (1300 MHz). 1300 BURST Enables measurement of burst signals from 100 MHz to 1.3 GHz (1300 MHz). CH A 125 Enables Channel A measurement of signals from 10 Hz to 125 MHz.

Table 2-1. 7220A Front Panel Controls, Indicators, and Connectors (cont)

REF. NO.	NAME	FUNCTION
		.1 FILT — Enables Channel A measurement of signals from 10 Hz to 100 kHz by switching in a 100 kHz Low Pass Filter. RES MULT — If the -351 Option is installed, this position enables the 10 kHz resolution multiplier and changes the scale of the RESOLUTION control. The 100 kHz Low Pass Filter is switched in. If the -351 Option is not installed, selection of this mode will prevent the instrument from counting.
10	RESOLUTION Control	Four-position slide switch which allows resolution selection of 100 Hz, 10 Hz, 1 Hz, or .1 Hz. If the -351 Resolution Multiplier Option is installed, the range of resolution is extended to include .01 Hz, .001 Hz, and .0001 Hz selections, and is color-coded by a blue band with the appropriate Function control position. Moving the slide switch between positions automatically generates the instrument's Reset command.
11	RESET	Pushbutton switch that resets the counters and zeros the display. The number 888888888 is displayed while the button is pressed to allow a visual check of the LED display segments.
12	POWER switches	These two push-push switches allow selection of instrument power source. BAT/LINE — If the -010 Battery Option is not installed, this switch will not affect instrument operation. If the -010 Battery Option is installed, this switch allows selection of either battery or line power. ON/STBY — The ON position enables normal operation. The STBY position powers the oven (with rear panel REF switch set to INT) and battery charging circuits if these options are installed.

2-18. OPERATING NOTES

2-19. The following paragraphs provide information which should be considered before operating the 7220A. This includes information about basic frequency counter operation and descriptions of the 7220A operating modes.

2-20. AC Line Connection

2-21. The input power cord is a three-pin polarized connector which permits connection through the rear panel power receptacle to any of the power voltages described under Input Power. Ensure that the ground pin is connected to a high quality earth ground.

2-22. Maximum Input Levels

CAUTION

To prevent instrument damage, do not connect the active lead of the input signals to the shell of the BNC connector. All BNC connector shells on the 7220A are tied directly to earth ground through the power plug.

2-23. Three of the four BNC connectors on the 7220A are designed to accept signal inputs. Two are on the front panel and allow input signals to be ac-coupled to the two input channels. The third input connector is on the rear panel and is the EXT REF input. Refer to Table 2-4 for the maximum signal input levels.

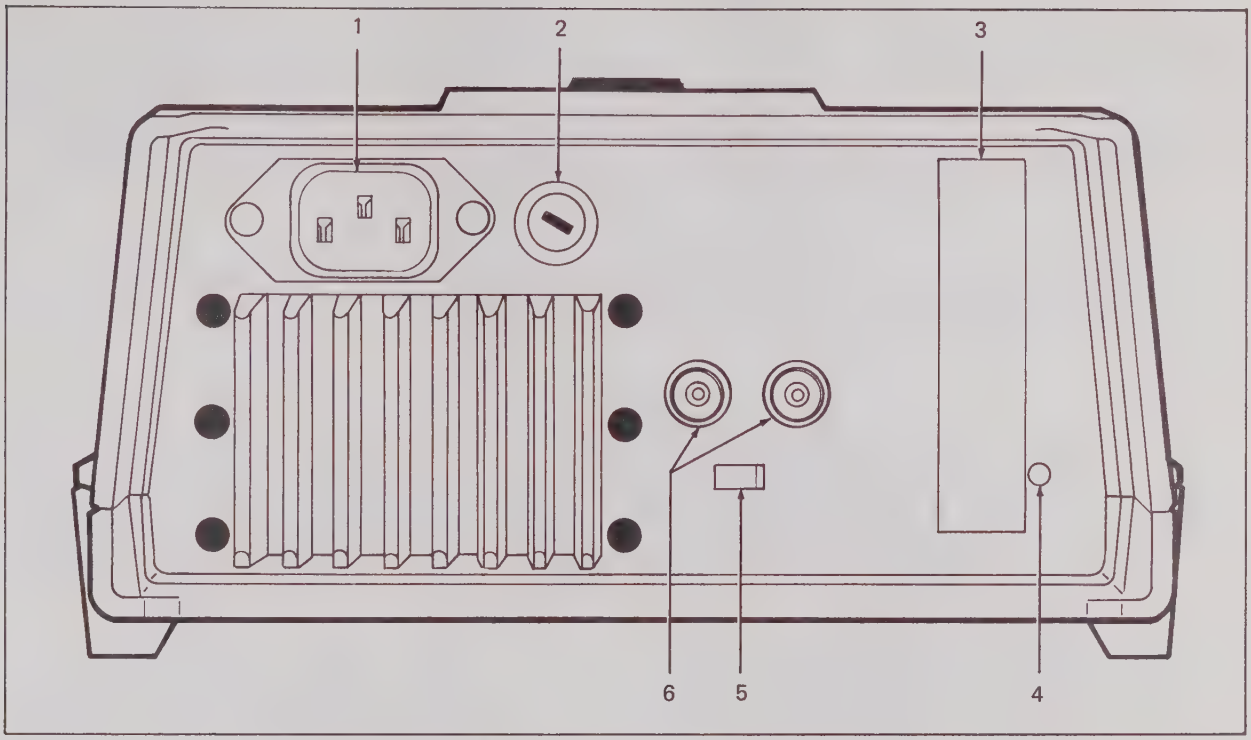


Figure 2-3. 7220A Rear Panel Controls, Indicators and Connectors

Table 2-2. 7220A Rear Panel Controls, Indicators, and Connectors

REF. NO.	NAME	FUNCTION
1	Input Power Connector	A 3 prong receptacle for ac line input.
2	F1	Fuse holder that houses the ac line power fuse and allows easy access for fuse replacement.
3	DATA OUT OPT. -521	Connector location for the Digital Interface, Option -521. When the -521 is not installed, the hole is covered by a removable panel.
4	FREQ ADJ OPT. -111	If the Option -111 time base is installed, this is the access point for adjusting the TCXO frequency. This adjustment is made during calibration only.
5	INT/EXT REF Switch	Two position slide switch that determines whether the instrument is clocked by the 10 MHz internal timebase (INT position), or by an external timebase (EXT position) connected to the 10 MHz REF IN connector rear panel.
6	10 MHz REF	
	IN	BNC connector for connecting an external timebase. This input is used only when the INT/EXT REF switch is in the EXT position.
	OUT	BNC connector which allows access to the timebase signal being used by the instrument.

Table 2-3. Counter Terminology

Attenuation

Attenuation is used to limit the input signal within the dynamic range of the input amplifier. The 7220A has two attenuators for use with Channel A. One allows variable attenuation from X1 to X10, and the other allows step attenuation from X1 to X10. They can be used separately or in combination to provide total attenuation from X1 to X100.

Gate Time

Gate time refers to the length of time during which an input frequency is being counted for display. In the 7220A, the gate time is determined by the resolution selected (see Table 2-5). The greater the degree of resolution, the longer the gate is open.

Hysteresis

In frequency counters such as the 7220A, proper counting requires a pulsed output from the input circuitry. To form this pulse, each input waveform (regardless of its shape) triggers a Schmitt trigger in the input circuit at predetermined triggering or hysteresis levels. An input waveform must pass through both of these hysteresis levels for the input circuitry to generate a pulse. The voltage difference between the two levels is termed the hysteresis window; the minimum signal that can trigger both levels therefore defines the sensitivity of the instrument. Generation of the hysteresis window and sensitivity is illustrated in Figure 2-4.

Input Impedance

The input impedance is the impedance seen by a signal source. Input impedance on Channel A is 1 megohm, shunted by 60 picofarads. Input impedance on Channel B is 50 ohms.

Linear Operating Range

The linear operating range refers to the excursions of the input signal that can reliably trigger the input amplifier without distortion. The linear range of the 7220A varies between the smallest signal level acceptable by the input amplifier (minimum) and the largest attenuated signal that will not be clamped by the input circuits in the amplifier (maximum). The minimum is defined by the sensitivity specifications of the instrument. Operation within maximum levels for Channel A may be ensured through proper use of the ATTENUATION controls.

Prescaling

This is a method of extending the frequency measuring range of a frequency counter by dividing the input signal before it enters the main gate. Thus, a lower-frequency signal is obtained which is coherent with the input signal, and lies within a range which the counter can accept. In the 7220A, the input signals to Channel B are prescaled (or divided) by a factor of 16. To compensate for this, gate times are increased by this same factor so that the counter will still obtain and display an accurate count for the high frequency range.

Resolution

This is defined as the smallest increment of frequency recognized by the counter and thus, the smallest displayed unit in a measurement. In the 7220A, this unit (the least significant digit, or LSD) is defined by each combined setting of the CH A/CH B and RESOLUTION controls.

Sensitivity

This is defined as the minimum specified input signal assured of triggering the instrument, and thus being reliably counted. This specification is related to the hysteresis window, temperature, and the characteristics of the amplifier. See hysteresis.

Trigger Level

This is defined as the voltage level nominally halfway between the upper and lower hysteresis levels. Trigger level is set at 0V in the 7220A and is not adjustable.

Table 2-4. Maximum Input Levels

INPUT TERMINAL	FREQ. RANGE	MAXIMUM INPUT
Channel A (See chart in Specifications, Table 1-3)	10 Hz to 5 KHz 5 KHz to 2 MHz 2 MHz to 125 MHz	250V rms Value linearly decreases from 250V rms at 5 kHz to 5V rms at 2 MHz. 5V rms
Channel B	100 MHz to 1300 MHz	5V rms
EXT REF		3V rms

2-24. Counter Terminology

2-25. Table 2-3 contains definitions which are useful in understanding how and when to use the 7220A controls. These terms are used throughout the manual.

2-26. ACCURACY

2-27. The following paragraphs discuss some of the possible sources of error when making frequency measurements, and some techniques for minimizing these errors.

2-28. One Count Error

2-29. The one count ambiguity, inherent in any gate and counter type of frequency meter, results from an out-of-phase relationship between the pulse train of the input circuit and the pulse train from the timebase. The effect is demonstrated in Figure 2-5. Both Signal A and Signal B have a frequency of 9.5 Hz. But over the same gate time of 1 second, the in-phase Signal A accumulates 10 counts, while the out-of-phase Signal B accumulates only 9 counts. This ambiguity can show up in the measurement as an error of ±1 count. Since this affects the least significant digit (LSD) of the measurement, the one count error can be reduced by selecting a greater degree of resolution. The error caused by this is calculated as follows:

$$\text{Error} = \pm 1 / \text{Input Frequency}$$

2-30. Signal Noise, Attenuation, and Filtering

2-31. The extreme sensitivity of the input circuitry of the counter can cause inaccurate counting if there is a significant amount of noise on a large signal. Figure 2-6a shows how this can occur. The input signal is much larger than is needed to transit the hysteresis, and the high frequency noise that is riding on the input signal is of a large enough amplitude that it can also transit the hysteresis window. This causes the extra count shown in Figure 2-6a. This extra count can be eliminated by proper use of the attenuation controls. As illustrated in Figure 2-6b, the input signal and the noise have been attenuated so that the noise does not transit the hysteresis window and correct counting takes place.

2-32. Incorrect counting can also take place if the input signal is overattenuated. In this case, the input signal may be reduced so that it does not always transit the hysteresis window, thus leaving out counts. This is often indicated by an unstable, fluctuating display.

2-33. If the Channel A input signal being measured is below 100 kHz, the 100 kHz low pass filter can be used to eliminate noise that is above 100 kHz. This filter is switched into the Channel A input circuit whenever the front panel CH A/CH B FILT .1 MHz mode is selected, or the Resolution Multiplier Option -351 is installed and the CH A/CH B RES MULT mode is selected.

2-34. Time Base Error

2-35. All crystal oscillator time bases drift in frequency and are thus subject to error. This frequency drift is due to fluctuation in temperature, fluctuation in line voltage, and crystal aging. These effects can be compared in the specification table in Section 1 of this manual. The greatest error is due to temperature fluctuation. This can be reduced by maintaining a stable temperature in the environment in which the instrument is being used. Consideration should be given to the proximity and temperature fluctuation of other instruments, particularly when stacking instruments. The instrument should also be allowed proper warmup time (typically 10 minutes).

2-36. Another way to reduce time base error due to temperature fluctuation is to install one of the optional time bases described in Section 6 of this manual. Option -111 is designed with a temperature compensating element to improve accuracy, and Options -131 and -132 house the crystal in an oven to minimize temperature changes. Time base error can also be reduced by using an

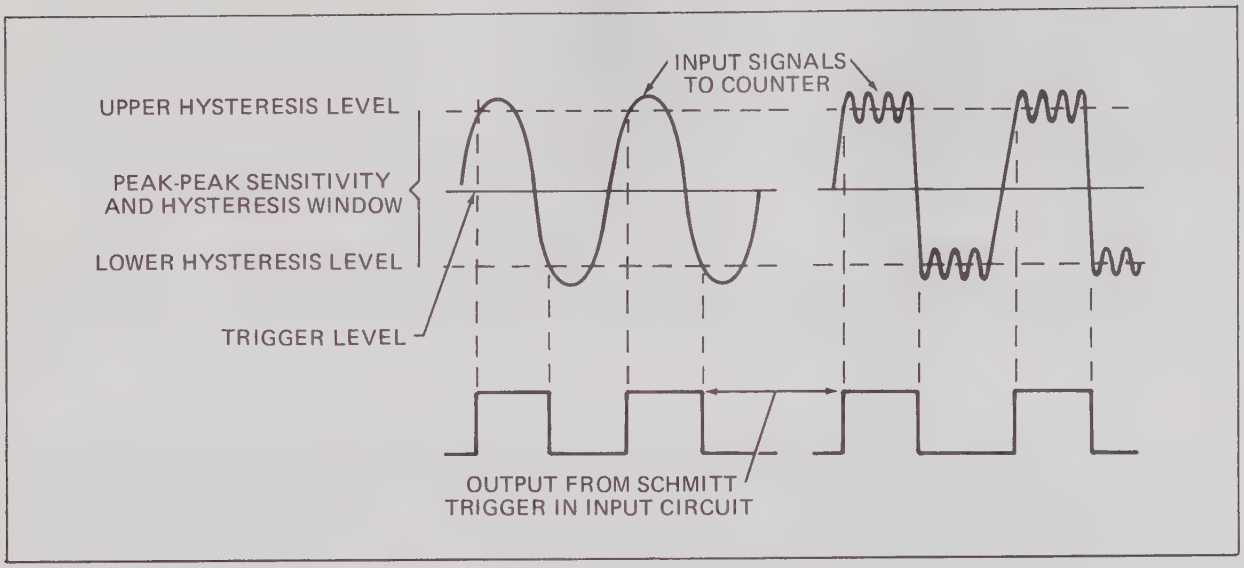

INPUT SIGNALS TO COUNTER
UPPER HYSTERESIS LEVEL
PEAK-PEAK SENSITIVITY AND HYSTERESIS WINDOW
LOWER HYSTERESIS LEVEL
TRIGGER LEVEL
OUTPUT FROM SCHMITT TRIGGER IN INPUT CIRCUIT

Figure 2-4. Hysteresis Window and Sensitivity

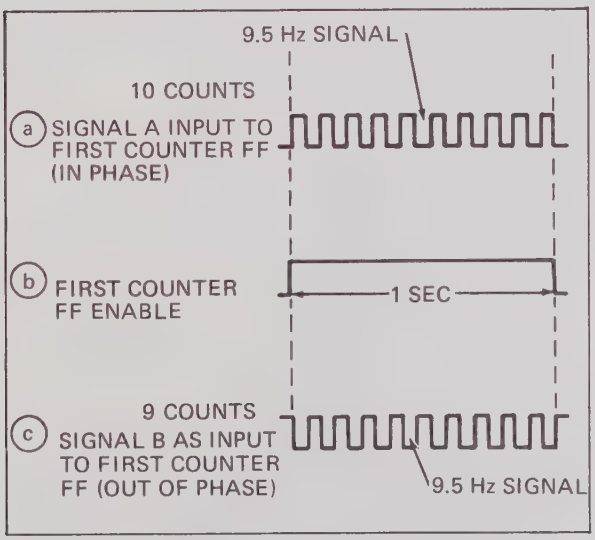

9.5 Hz SIGNAL
10 COUNTS
a SIGNAL A INPUT TO FIRST COUNTER FF (IN PHASE)
b FIRST COUNTER FF ENABLE
1 SEC
9 COUNTS
c SIGNAL B AS INPUT TO FIRST COUNTER FF (OUT OF PHASE)
9.5 Hz SIGNAL

Figure 2-5. One Count Error

external timebase that is more stable and accurate as an external reference. To connect an external timebase, place the REF switch on the rear panel in the EXT position and connect the external timebase to the 10 MHz REF IN terminal on the rear panel.

2-37. Total Error Calculation

2-38. Assuming that signal noise and distortion are not causing false triggering and counting, frequency measurement error can be calculated using the following formula:

Frequency measurement error = ±1 count ± time base error

2-39. OPERATION

2-40. Use the following procedures to operate the 7220A. Refer to the previous paragraphs if necessary. Pay particular attention to the turn-off procedure if the Option -010 Battery Pack is installed.

2-41. Initial Procedure

2-42. The following procedural checks should be performed prior to operating the 7220A.

1. Check that the instrument has been connected to appropriate line power.
2. On the rear panel, ensure that the REF switch is set to INT.
3. Set the ON/STBY switch to the ON position.
4. Allow adequate time for instrument warmup, especially if an optional oven time base is installed (typically 10 minutes).
5. If the Option -010 Battery Pack is installed, set the BAT/LINE switch to the desired position.

2-43. Frequency Measurements — CHANNEL A

2-44. Frequencies from 10 Hz to 125 MHz can be counted and directly displayed using Channel A. Use the following procedure:

1. Connect the input signal to the Channel A BNC connector.

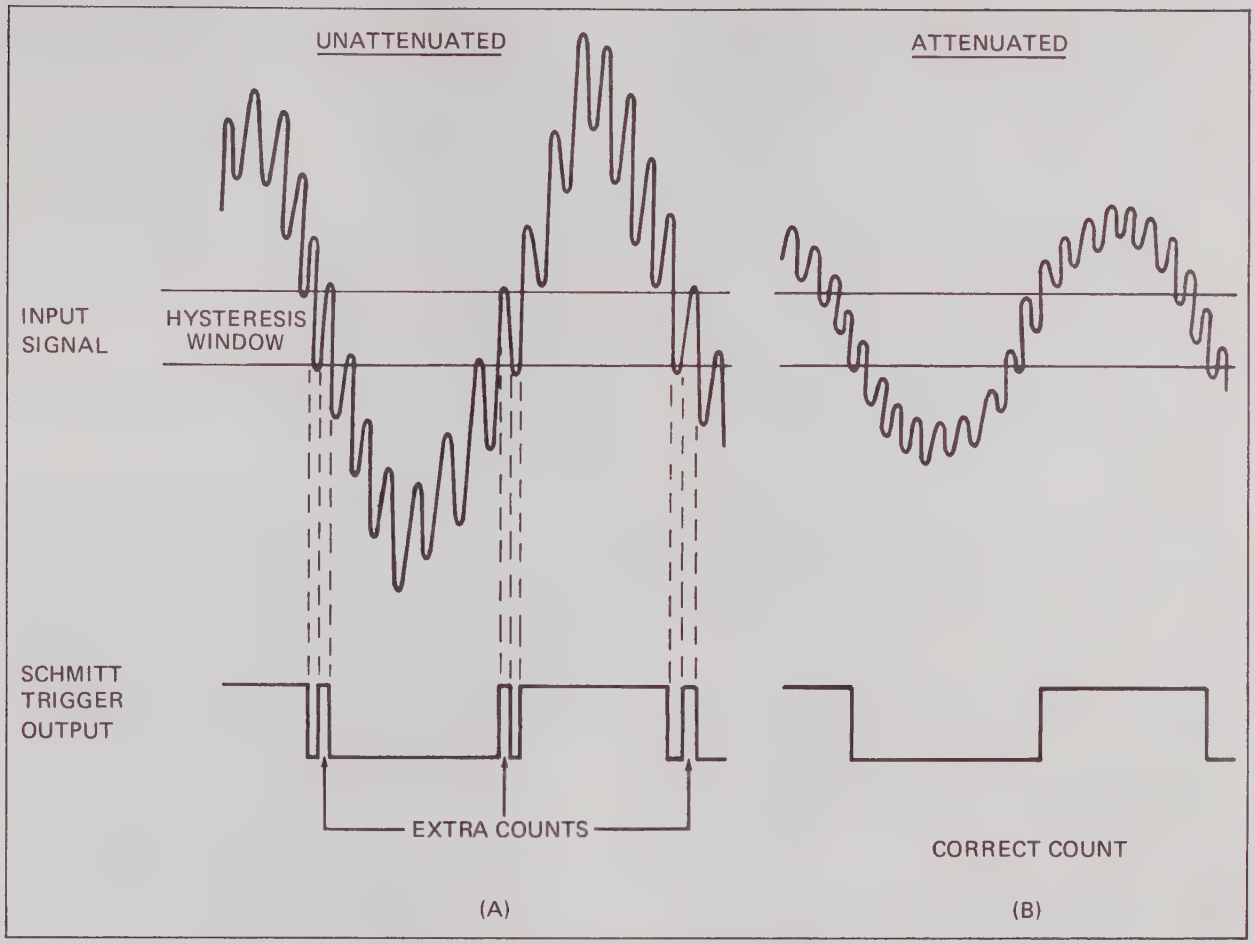


Figure 2-6. Signal Noise and Attenuation

2. Set the CH A/CH B switch to the 125 MHz position.

3. Set the RESOLUTION switch to the desired resolution.

4. Adjust the ATTENUATION controls to obtain a stable display. Attenuating the signal to just above instrument sensitivity will reduce false triggering to a minimum while leaving signal strength high enough to ensure positive triggering.

5. If the input signal is below 100 kHz, eliminate high frequency noise by setting the CH A/CH B switch to the FILT .1 MHz position.

6. If the Option -351 Resolution Multiplier is installed and higher resolution is desired for signals below 10 kHz, move the CH A/CH B switch to the RES MULT position. The RESOLUTION switch is now scaled up by a factor of 1000 so that the 100 Hz, 10 Hz, 1 Hz, and .1 Hz resolution settings are now .1 Hz, .01 Hz, .001 Hz, and .0001 Hz respectively. The Option -351 Resolution settings and the Hz measurement unit are color-coded to the RES MULT position by a blue band on the front panel.

7. Read the frequency on the display and observe the units of measurement (MHz or Hz) to the right of the display. The OVFL annunciator should not be illuminated.

2-45. Frequency Measurements — CHANNEL B

2-46. Frequencies from 100 MHz to 1300 MHz can be counted and directly displayed using Channel B. Use the following procedure:

1. Connect the input signal to the Channel B BNC connector.

2. To measure continuous wave signals, set the CH A/CH B switch to the 1300 MHz position. Measurements are taken consecutively, and the display is updated continuously.

3. To measure burst signals, set the CH A/CH B switch in the BURST position. The first burst signal that arrives at the input triggers one measurement cycle, and this measurement is displayed without being updated. Subsequent measurement cycles are held off while in the burst mode until the signal level on the input is reduced below the Channel B reference threshold level. This prepares the counter to receive, measure and display another burst signal. If the signal carrier level between bursts is greater than the Channel B reference threshold level, it will be necessary to externally attenuate the signal being measured to accomplish this. To measure burst signals, bursts must be present for at least 40 ms + gate time, where gate time = 16/Resolution. For gate times, see Table 2-5.

Table 2-5. Resolution Settings and Gate Times

Resolution Setting (Hz)	100	10	1	0.1
Resolution Multiplier Setting-Channel A only (Hz)	0.1	0.01	0.001	0.0001
Gate Time (sec) — Channel A . . .	0.01	0.1	1	10
— Channel B . . .	0.16	1.6	16	160

2-47. Self Check Mode (CHK)

2-48. The self-check function is used to verify the overall operation of the counter, excluding time base accuracy and the input circuitry. Each setting of the RESOLUTION control provides a predictable display of the 10 MHz reference signal generated by the internal time base. To self-check the 7220A, use the following procedure:

1. Set the CH A/CH B switch to CHK.

2. Momentarily press the RESET control. The display should read 888888888 while RESET is pressed. This resets all the counters and zeros all the display latches.

3. Verify correct display for each of the RESOLUTION settings as defined in Table 2-6.

Table 2-6. CHK Function Display

RESOLUTION SWITCH SETTING	DISPLAY
0.1 Hz	10.0000000 MHz
1 Hz	10.000000 MHz
10 Hz	10.00000 MHz
100 Hz	10.0000 MHz

2-49. Turn Off Procedure

2-50. When the Option -010 Battery Pack is not installed in the 7220A, use the following procedure to turn off the instrument:

1. Set the ON/STBY switch to the STBY position. This will remove power from most of the circuits, but the transformer, regulators, and associated circuitry will still be connected to line power. Also, if either of the two optional oven time bases (Option -131 or -132) is installed, it will receive power if the rear panel REF switch is set to INT. This is indicated by the front panel OVEN annunciator which is illuminated when an oven time base is receiving power. To remove power from an oven time base, set the rear panel REF switch to EXT.

2. To remove line power from the 7220A transformer, regulators, and associated circuitry, disconnect the ac power cord.

2-51. When the Option -010 Battery Pack is not installed, the BAT/LINE switch will have no effect on the operation of the instrument. When the Option -010 is installed, use the turn off procedure outlined above when the BAT/LINE switch is set to LINE. When Option -010 is installed and the BAT/LINE switch is set to BAT, use the following turn off procedure:

1. Disconnect the ac line power cord, if it is not already disconnected.

2. Set the ON/STBY switch to STBY. This will remove battery power from the instrument, but if either of the two optional oven time bases is installed, it will still receive power from the battery if the rear panel REF switch is set to INT. To remove power from an oven time base, set the rear panel REF switch to EXT.

Section 3
Theory of Operation

3-1. INTRODUCTION

3-2. The theory of operation of the 7220A Frequency Counter is presented on two levels. The first is an overall functional description of the 7220A. This is followed by a detailed analysis of the logic and circuits of each major functional element in the counter. The text is supported in this section by functional block diagrams, tables, simplified circuit diagrams, and by the complete instrument schematics in Section 8 of this manual.

3-3. OVERALL FUNCTIONAL DESCRIPTION

3-4. Introduction

3-5. The 7220A Frequency Counter is designed to measure a wide range of frequencies with two possible input channels. Channel A allows the lower range measurement, and includes a selectable 100 kHz low pass filter. Channel B allows higher range prescaled frequency measurement up to 1300 MHz. The Channel B BURST mode allows measurement of high frequency bursts up to 1300 MHz. A self check mode is also provided to check the internal circuitry of the counter. There are several resolution settings that can be selected, as well as an optional resolution multiplier that is fully described in Section 6 of this manual.

3-6. Basic Counter Block Diagram

3-7. To understand the operation of the 7220A, it is helpful to first look at the basic operation of a digital electronic frequency counter. The basic elements of the counter are shown in Figure 3-1. The frequency of a signal can be described by the equation $f = n/t$, where f is the average frequency found by accumulating n cycles of the signal over the time period t. The frequency measurement is accomplished by counting the number of cycles n of the unknown signal over a period t, which is precisely established by a very accurate reference time base and time base dividers. This procedure is illustrated in Figure 3-1.

3-8. The input signal is applied to the signal conditioner which conditions the signal to a form that is compatible with the internal circuitry of the counter. The signal conditioner also shapes the signal into a square wave, which is then presented to the main gate for counting.

3-9. The main gate is the heart of the counter, for when it is open, it allows the preconditioned input signal to pass through and be counted. In some counters, there is a separate logic gate whose only function is to serve as the main gate. In the 7220A, however, the main gate function is served by the First Counter flip flop in the counter series. To "open" or "close" the main gate actually means this First Counter FF is being enabled or disabled. The amount of time the First Counter FF is enabled is called the gate time. The First Counter FF is enabled or disabled by the main gate flip flop which responds to output pulses from the time base dividers.

3-10. The events required to make a frequency measurement occur as follows: The operator selects the measurement resolution desired. This tells the time base dividers how long the First Counter FF is to be enabled, or in other words, what division factor to apply to the time base reference frequency. The time base dividers trigger the main gate flip flop which enables the First Counter FF, beginning the gate time. While the counters count the unknown frequency, the time base dividers divide the reference frequency by the factor selected. When this is completed, the main gate flip flop is triggered again. This disables the First Counter FF, ending the gate time, and the measured signal is displayed. The timing for these events is presented in Figure 3-1.

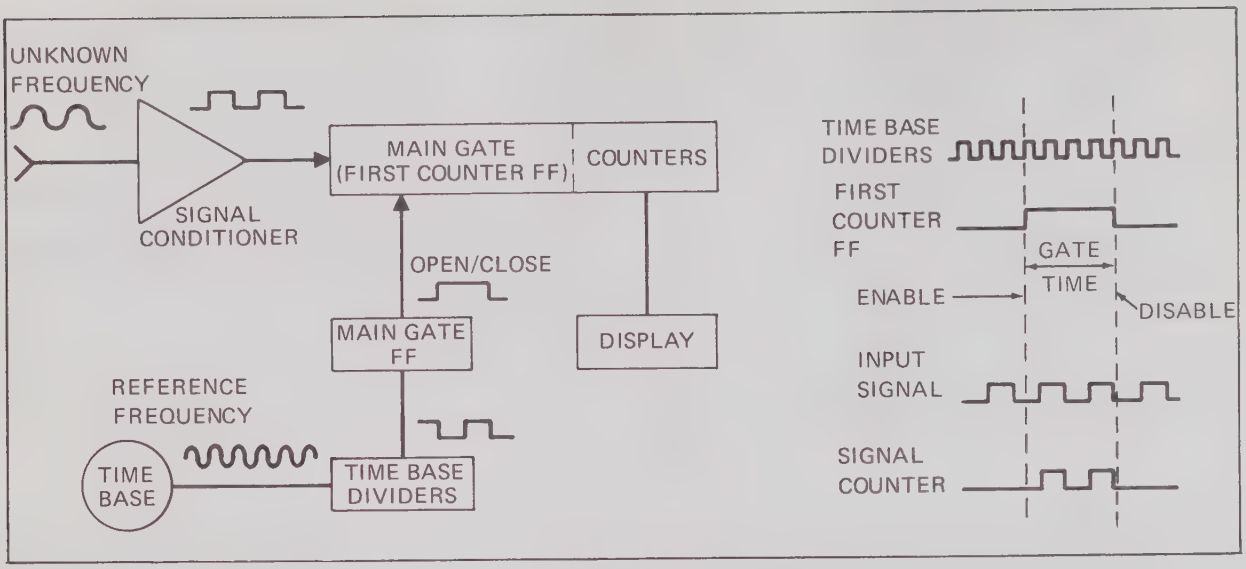


Figure 3-1. Basic Counter Block Diagram

3-11. FUNCTIONAL BLOCK DIAGRAM

3-12. Major functional areas of the 7220A are shown in Figure 3-2. The operation of each block is described in the following paragraphs.

3-13. Measurement Controls

3-14. The measurement controls consist of the Resolution Control and the Function Control. These are the front panel RESOLUTION and CH A/CH B slide switches, and their function depends on the position of the switch. The Resolution Control supplies decimal point placement information to the display decoder, and measurement range information to the main time base divider. The Function Control supplies mode selection information to the Control Logic and the Input Select.

3-15. Control Logic

3-16. The Control Logic governs the sequence of events in the counter, including the time base division and counting. It receives information from the Function control, including burst and reset modes. It generates reset commands for the Main Time Base Divider and the accumulators, and it clears the Main Gate Flip Flop. It also generates the strobe command for the display latches.

3-17. Time Base and Dividers

3-18. The Time Base generates the 10 MHz reference signal which is used to provide the precise timing needed for the internal signal counters. The 10 MHz is generated by the standard internal oscillator, one of the optional TCXO or oven oscillators, or by an external time base whose signal is applied at the rear panel of the instrument. The Time Base Dividers receive measurement range instruction from the Resolution Control. They divide the 10 MHz by the proper amount to provide the Control Logic and First Counter FF with the proper timing needed to generate the actual required gate signal.

3-19. First Counter Flip Flop and Main Gate Flip Flop

3-20. As mentioned in the previous section on the basic counter block diagram, some counters have a separate logic gate (sometimes called the "main gate") whose only function is to allow or prevent passage of the unknown frequency into the counters to be counted. In the 7220A, however, this main gate function is served by the First Counter FF, which is the first counter in the counter series. While the First Counter FF is enabled, the unknown frequency is counted, but while it is disabled, no counting takes place. The interval during which the First Counter FF is enabled is called the gate time. The First Counter FF is enabled or disabled by the Main Gate FF, which operates through the Gate Synchronizer FF. The First Counter FF responds to instructions from the Control Logic and the Time Base Dividers.

3-21. Counters

3-22. There are nine decade BCD counters that tally the number of counts received while the First Counter FF is enabled, and present the information to the Display Latch and Multiplexer function. The first decade BCD counter is actually a series of four flip flops, the first of which is the First Counter FF described above.

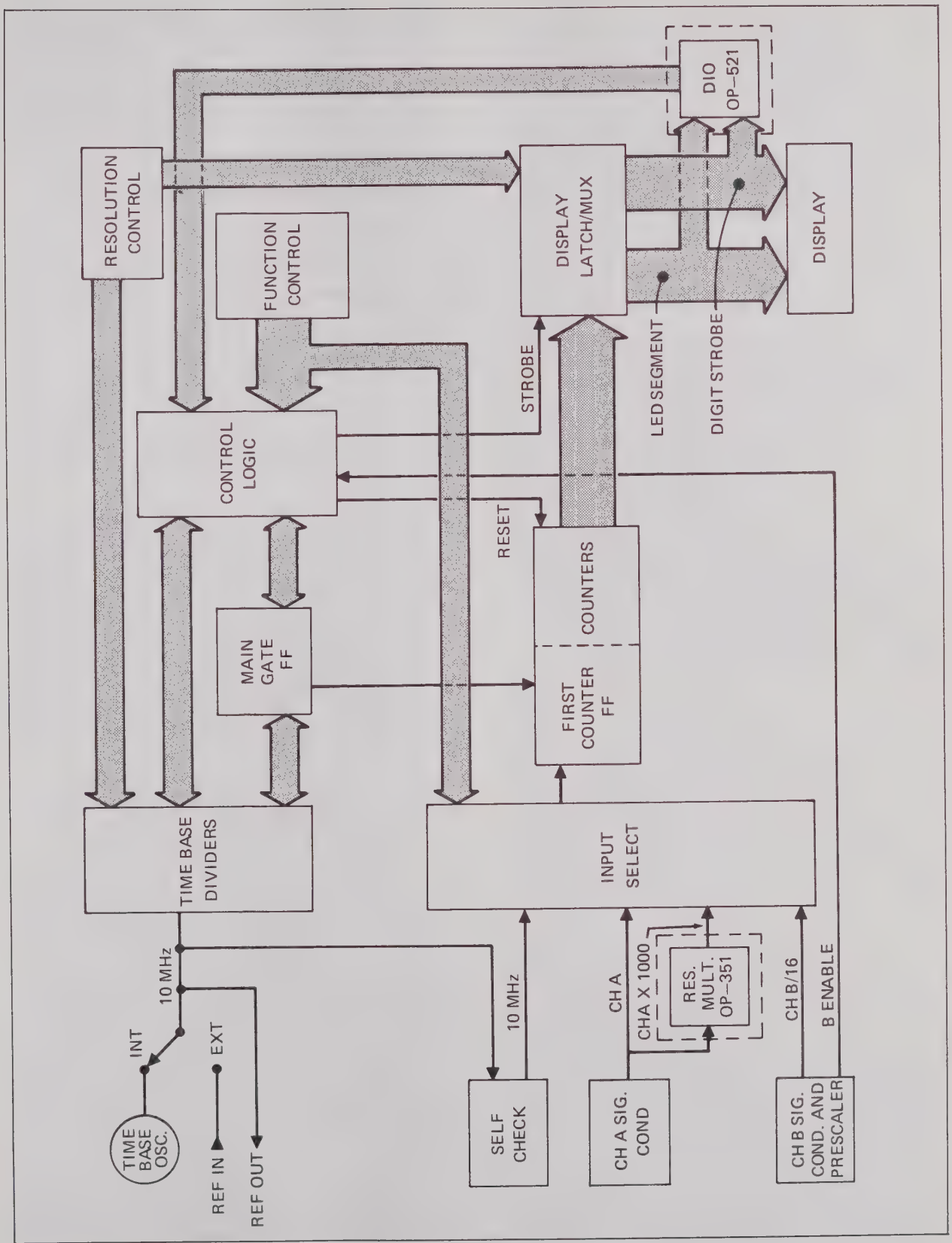


Figure 3-2. 7220A Functional Block Diagram

3-23. Input Select

3-24. The Input Select responds to instruction from the Function Control, and it supplies the First Counter FF with one of four possible input signals. When CH A is selected, the squared signal from the Channel A Signal Conditioner is used as the input. When CH B is selected, the shaped and prescaled signal from Channel B is the input. If the optional RES MULT is selected, the input is the Channel A input signal multiplied by 1000. Finally, with CHK selected, the 10 MHz time base signal serves as the input.

3-25. Channel A Signal Conditioners

3-26. Channel A can receive input of 10 Hz to 125 MHz. The ac-coupled signal can be filtered or attenuated, and is passed into a preamplifier, where it is squared and conditioned before being presented to the Input Select.

3-27. Resolution Multiplier Option -351

3-28. The optional Resolution Multiplier provides X1000 multiplication of Channel A input frequencies from 10 Hz to 10 kHz by means of a phase-locked loop. More counts can therefore be accumulated during gate times, and this effectively increases the resolution. This option is fully described in Section 6 of this manual.

3-29. Channel B Signal Conditioners

3-30. The 100 MHz to 1300 MHz input signal is received through Channel B, and prescaled or divided by a factor of 16. For example, a 1200 MHz input signal is actually seen by the counters as a 1200/16 = 75 MHz signal. To compensate for this prescaling of the frequency, there is a special Channel B time base divider (the Binary Divider) which increases the gate time by this same factor of 16, thus increasing the count accumulated so that the correct reading of 1200 MHz is actually displayed. The Channel B signal is also amplified and buffered in this block before prescaling.

3-31. The input circuits are on a hybrid which also contains a threshold detector. The input signal is compared to an adjustable reference threshold signal level, and if it is equal to or greater in amplitude, then the detector enables the Control Logic to initiate the counter's measurement cycle. If the input signal is below the reference threshold, the Control Logic inhibits the measurement cycle of the counter. When the Channel B BURST mode is selected, the B Enable notifies the Control Logic when an input is detected.

3-32. Self Check

3-33. The purpose of this block is to provide a way of checking counter operation without applying external signals. It applies the 10 MHz signal from the time base of the counter to the clock input. Since the measurement is based on the counter's own time base, the input signal conditioners are not checked, but correct operation can be verified for the Time Base Dividers, the Main Gate FF, the Counters, the Control Logic, the Display Latch and Multiplexer, and the Display.

3-34. Display Latch and Multiplexer

3-35. The Display Latch and Multiplexer takes the accumulated data and presents the multiplexed strobe and data information to the Display function and the Digital Interface Option -521.

3-36. Display

3-37. The Display is a 9 digit LED display with decimal point. There are also 3 LED annunciators which provide information about the gate time interval, display overflow, and optional oven time base power.

3-38. Digital Interface Option -521 (DIO)

3-39. The Digital Interface supplies the data to the bus lines for use directly with a companion printer or with an 1120A Translator for IEEE-488 compatibility. When used with the 1120A Translator, the Interface PCB Assembly Option -522 must be installed in the 1120A. When properly connected with Option -522 and the 1120A, the Digital Interface allows remote sampling of instrument measurements, reset control, and selection of single or continuous measurements.

3-40. LOGIC AND CIRCUIT ANALYSIS

3-41. Power Supply

3-42. The 7220A uses conventional ac to dc rectifying, filtering and regulating techniques to obtain the +5V, -5V, +12V, -12V, and Channel B -1.8V operating voltages. The 7220A is fuse protected at the ac line connection by fuse F1. The ac power enters through the rear panel power connector and passes to the voltage selection switches S4 and S5 on the primary side of transformer T1. Correct configuration of S4 and S5 allows accommodation of line voltages of 100V, 120V, 220V, or 240V. Information about the procedure for changing voltage selection can be found in Section 4. The secondary side of T1 feeds full wave rectifier bridges CR1 and CR2, which provide the unregulated +12V, -12V, +5V, and -5V supplies. The +12V and -12V are regulated by regulators U40 and U42. The +5V passes through the adjustable regulator U41. The three regulated lines then pass to the front panel ON/STBY switch.

3-43. Since the 7220A has no separate ac power switch, ac power is always applied to the transformer, bridges, and regulators when the power cord is connected. When the ON/STBY switch is in the ON (depressed) position, power is supplied to the internal circuits. When the ON/STBY switch is in the STBY position, power is removed from the internal circuits, but is supplied to any optional oven time base that is installed (when the rear panel REF switch is set to INT) to eliminate the need for oven warm-up time. The front panel OVEN LED annunciator indicates that an oven time base is receiving power.

3-44. The regulated +5V line passes to the front panel BAT/LINE switch. When the Battery Pack Option -010 is not installed, the position of the BAT/LINE switch has no effect on instrument operation. Refer to Option -010 in Section 6 for a discussion of the battery option circuitry. The Channel B high speed counter -1.8V voltage regulation is described in the Channel B Signal Conditioner section.

3-45. Channel A Signal Conditioners

3-46. The Channel A signal conditioners consist of voltage divider attenuators, current limiters, a high impedance FET buffer, and a preamplifier IC that consists of a differential input amplifier, a Schmitt trigger, and ELC and TTL logic drivers. As can be seen in Figure 3-3, the Channel A signal enters at the front panel BNC and passes to the main voltage dividers, resistors R1 and R2, which provide attenuation of X10. The X10 attenuation can be selected by positioning the front panel ATTENUATION slide switch. The signal then passes through the current limiting and clamping network consisting of resistors R3 and R4, and diodes CR1 and CR2. This limits the signal presented to the gate of the high impedance buffer, FET Q1, to 1.2V p-p. Q1 is a low frequency device, so capacitor C5 provides a high frequency path around it. The signal is ac-coupled through C6 to one input of the differential input amplifier on the preamp IC, U1. A dc return path is provided by R7.

3-47. PREAMP IC

3-48. Most of the signal conditioning takes place in the preamp IC U1. U1 is enabled by the front panel Function control when one of the three Channel A modes is selected, and is off when Channel A is not in use. U1 requires +5V and -5V power supplies for operation. The +5V supply passes through choke L1 before arriving at U1. The -5V supply is obtained from the three terminal regulator U2, which drops a -12V supply to the required -5V.

3-49. The amplifier in U1 has a dynamic operating range which is well beyond the 1.2V p-p range allowed by the signal clamps R3, R4, CR1 and CR2. Normally, the amplifier has a 3 dB bandwidth which ensures adequate handling of Channel A's 10 Hz to 125 MHz input signal range. For low frequency signals, however, a low pass 0 to 100 kHz filter can be switched in by selecting front panel CH A/CH B position CH A FILT (if the Resolution Multiplier Option -351 is installed, the CH A RES MULT position will also switch in the filter). This turns on transistor Q2, which switches capacitor C12 into the amplifier circuit. The value of C12 determines the low pass filter bandwidth, which in this case is 100 kHz.

3-50. The amplifier trigger level is adjusted by potentiometer R10. The R10 setting is an internal adjustment, and is adjusted during instrument calibration to compensate for the amplifier offset. This procedure can be found in the Calibration Adjustments in Section 4. Variable attenuation of Channel A signals can be achieved by adjusting R12, which controls the gain of the amplifier. R12 is actually the upper attenuation control which is accessible from the 7220A front panel. R12 allows a variable attenuation range up to X10, and when used in conjunction with the X10 step attenuator, allows a total attenuation range of X100.

3-51. SCHMITT TRIGGER

3-52. As can be seen in Figure 3-3, the signals pass from the amplifier to the Schmitt trigger, where the waveform is shaped into a pulse train suitable for counting. The width of the hysteresis window can be varied by adjusting R11. This is an internal adjustment, and proper adjustment procedure is described in the Calibration Adjustments in Section 4.

3-53. The ECL driver on U1 drives Channel A ECL (thus the mnemonic AECL) and complementary ECL ($\overline{\text{AECL}}$) logic level signals to the Input Select for counting. The TTL driver is powered only when the CH A/CH B switch is in the RES MULT mode, and it provides Channel A TTL (ATTL) logic level signals for the Resolution Multiplier Option -351. The Resolution Multiplier multiplies the low frequency signals by 1000, and presents the X1000 signal to Input Select for counting, thus increasing signal resolution. Resolution Multiplier operation is described more fully in Section 6.

3-54. Channel B Signal Conditioners and Prescaler

3-55. The 100 MHz to 1300 MHz Channel B signals are amplified, prescaled (divided by 16), and buffered before being presented to the 7220A Main Gate for counting. As can be seen in Figure 3-4, the amplification and first stage of frequency division takes place in the hybrid, U4. Also shown in Figure 3-4 is the threshold detect circuitry which indicates whether a valid Channel B input signal is present or not, and a tracking regulator which maintains a constant 6.8V across the signal dividers.

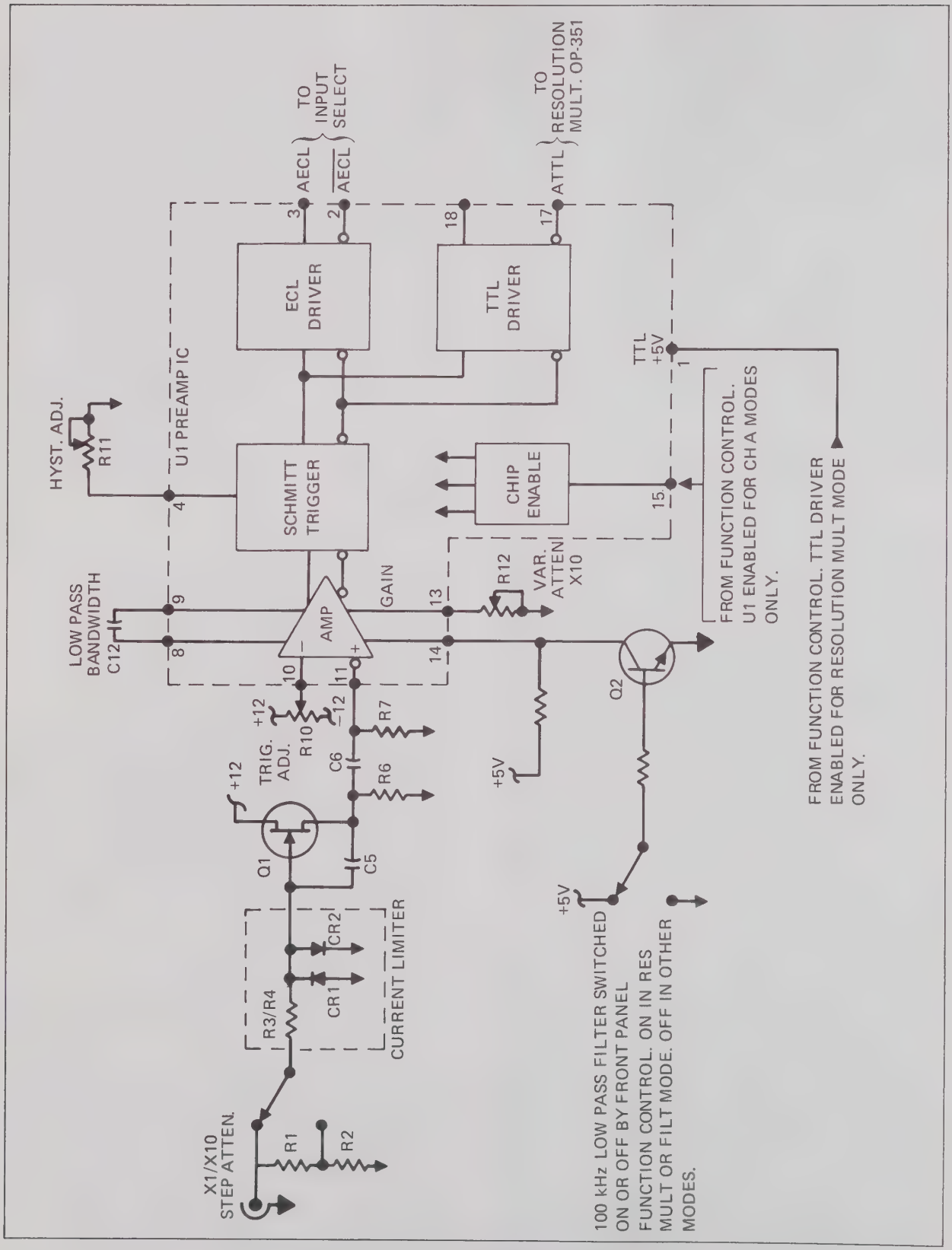


Figure 3-3. Channel A Signal Conditioners

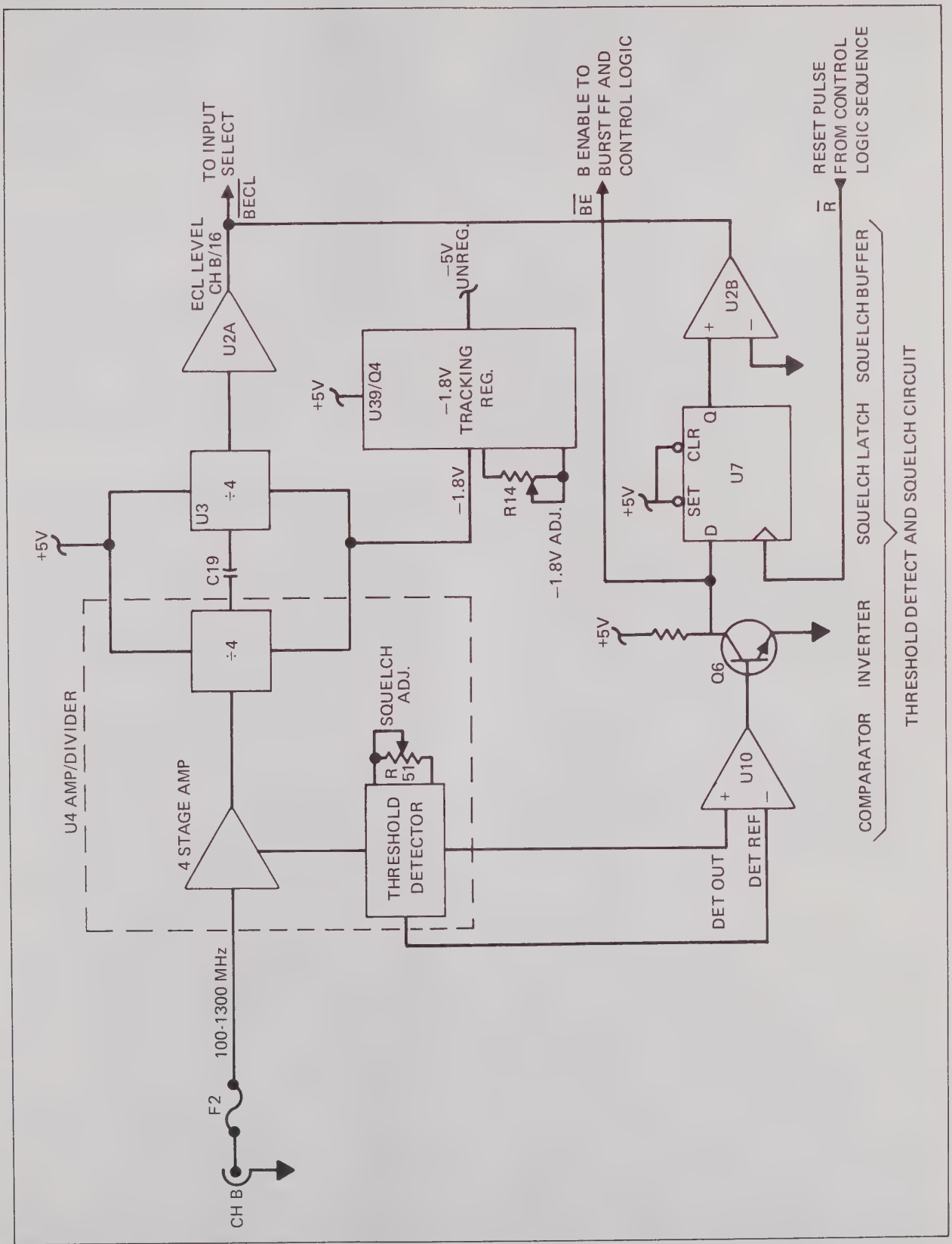


Figure 3-4. Channel B Conditioners and Prescaler

3-56. The Channel B input signals enter through the front panel BNC connector and pass through fuse F2, which provides voltage overload protection for the input circuitry. A spare, unconnected fuse, F3, is also located on the main PCB. The signals enter the high frequency four-stage amplifier on U4. The amplifier provides approximately 40 dB gain, and presents the signal to the high speed divider on U4 for prescaling.

3-57. PRESCALING

3-58. The purpose of prescaling is to extend the measurement range of the frequency counter by prescaling or dividing the input signal down to the operating range of the counters in the frequency counter. To compensate for this signal division, the First Counter FF is enabled longer so the proper number of counts are accumulated. This is described in detail in the theory of operation regarding the time base dividers. The Channel B 100 MHz to 1300 MHz input signals are prescaled by a factor of 16. This is accomplished by a very high speed divide-by-four ECL prescaler mounted on the hybrid, U4, and a second divide-by-four ECL prescaler, U3. The two prescalers are ac-coupled, and are shown in Figure 3-4. U3 has complementary outputs that provide ECL level signals to U2A, which buffers them, and presents the Channel B ECL level ($\overline{\text{BECL}}$) signal to the Input Select.

3-59. HIGH SPEED COUNTER VOLTAGE REGULATION

3-60. The high speed divide-by-four prescalers (one is mounted on the hybrid U4, and the other is U3) are sensitive to voltage fluctuation, and must be supplied with a constant 6.8V to operate properly. This is particularly important if the 7220A is being operated with batteries, since the voltage supply levels will sometimes drop. The 6.8V voltage regulation is accomplished by the tracking regulator U39 and transistor Q4. U39 tracks the +5V supply line, and operates with Q4 to supply the two prescalers with a constant 6.8V below the +5V line (or -1.8V). The 6.8V difference can be calibrated by adjusting potentiometer R14. See the Calibration Adjustments section in Section 4 for the proper procedure. When the 7220A front panel CH A/CH B switch is not in either of the two Channel B modes, transistor Q5 acts as a power switch that turns off U39, and transistors Q2 and Q3 act as power switches to remove the +12 supply from U4. Thus the Channel B input circuitry is off when not in use.

3-61. THRESHOLD DETECT CIRCUIT

3-62. In the absence of an input signal, the high-speed divide-by-four prescaler on U4 will oscillate, thus supplying an erroneous signal which would be counted and displayed by the frequency counter if not eliminated. To prevent this from happening, a threshold detect circuit is provided which determines whether an input signal is being applied that is above a preset reference level or threshold. If an input signal is above the threshold, then it is allowed to pass on through to the Input Select for counting and display. If, however, the input signal is below the threshold, the oscillation signal is squelched, or suppressed, and not allowed to pass through to the Input Select.

3-63. As can be seen in Figure 3-4, the threshold detect circuit begins on the hybrid, U4. U4 contains the threshold detector circuitry which tops the input signal between the third and fourth amplifier stages and passes a detector out level (Det Out) and a detector reference level (Det Ref) to the inputs of the comparator U10. The threshold or detector reference level is determined by the setting of a potentiometer, the Squelch Adjust, which is located on U4. The correct procedure for setting the Squelch Adjust can be found in Section 4 under Calibration Adjustments.

3-64. U10 compares Det Out with Det Ref. Either of two situations can arise: In the first case, if the Det Out is more positive than the Det Ref (indicating a signal above threshold), the output of U10 is high. Transistor Q6 inverts the high by turning on, thus presenting a logic low to the D input of U7, an edge-triggered D flip flop. Since both set and clear are tied high, U7 presents a logic low to the buffer U2B when it is clocked by a Reset pulse from the Control Logic Sequencer. U2B produces an ECL low signal which is tied to the output of buffer U2A. Since the outputs of U2A and U2B are wired together, they form a logic OR. In this case, with an ECL low signal from U2B, the prescaled Channel B signal ($\overline{\text{BECL}}$) from U2B passes through unhindered to the Input Select circuitry.

3-65. In the second case, however, the outcome is just the opposite. When the Det Out is less positive than the Det Ref, (indicating a signal is below threshold), the output of the comparator is low. Q6 inverts this to a high, which is passed by the D flip flop to buffer U2B. U2B produces an ECL high signal which is joined to the U2A output. This ECL high overrides any erroneous signal from the freely oscillating prescaler. Thus, until a valid input signal is present, no signal will be counted or displayed. The function of the B Enable ($\overline{\text{BE}}$) is described in the section on the Control Logic Sequencer.

3-66. Input Select

3-67. There are four possible input sources to the 7220A First Counter FF. As can be seen in Figure 3-5, each of the four possible sources are applied to one of the NOR gates on U8, a quad 2-input NOR gate. The gate sources are the prescaled Channel B signal (CH B/16), the 10 MHz timebase signal, the Channel A signal with the Resolution Multiplier Option -351, and the Channel A

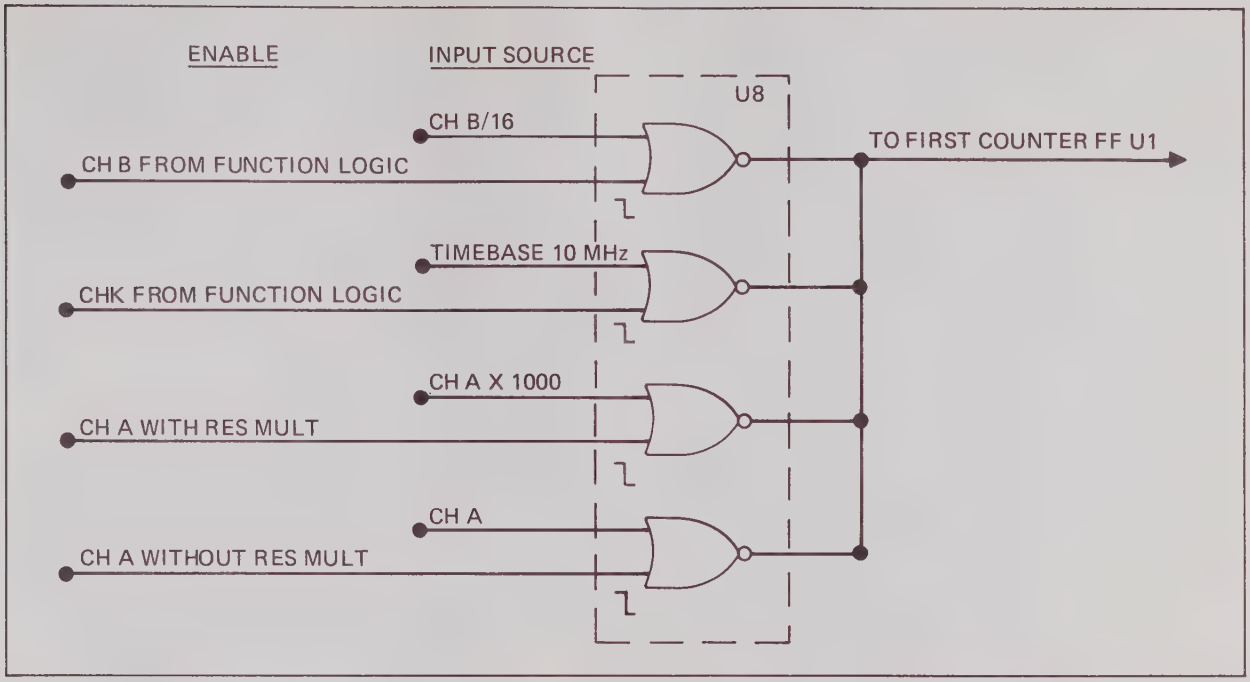


Figure 3-5. Input Sources

signal without the Resolution Multiplier. Depending on which Function is selected by the 7220A front panel CH A/CH B switch, the appropriate source is enabled by a logic low signal from the Function logic, and is applied to the First Counter FF for counting.

3-68. Time Base Dividers

3-69. The 7220A Time Base Dividers provide the accurate timing needed for the gate time intervals, as well as the clock for the Gate Synchronizer, and the scan rate for the Control Logic Sequencer. This is accomplished by dividing the 10 MHz reference signal from the time base according to instructions received from the CH A/CH B and RESOLUTION Controls.

3-70. As shown in Figure 3-6, there are three time base dividers: the Decade Divider, the Binary Divider, and the programmable Main Divider. The Decade Divider receives the 10 MHz time base signal and divides it to 1 MHz and 100 kHz. The 100 kHz signal is sent to the Gate Synchronizer, and is explained in the section about the Gate Synchronizer. The 1 MHz can follow one of two paths, depending on which Function is selected on the 7220A front panel Function Control switch. For Channel A modes, the 1 MHz is sent directly to the Main Divider.

3-71. For Channel B modes, the 1 MHz goes first to the Binary Divider where it is divided by 16 before being sent to the Main Divider. The 1/16 MHz division compensates for Channel B signal prescaling. The high frequency input signals coming into Channel B are prescaled (divided) by a factor of 16 to the operating range of the counters. To compensate for this slower input signal, the gate times are increased by the same factor of 16 (see Table 3-1) by dividing the Main Divider clock signal to 1/16 MHz. Therefore, even though the Channel B signal is divided by 16 by the time it reaches the First Counter FF, the gate times are 16 times longer, so the 7220A will count and display the proper frequency. The Binary Divider also provides the 61 Hz Scan Rate for the Control Logic Sequencer, U32, a decade ring counter. The 61 Hz is approximate, for it is actually 1 MHz divided by 2^{14}.

3-72. MAIN DIVIDER

3-73. The actual counting of the gate time intervals takes place in the Main Divider, U20. The Main Divider consists of a series of decade counters which can be selected according to binary code information received on the RNG 1 and RNG 2 lines. RNG 1 and RNG 2 are controlled by the front panel RESOLUTION Control setting, and they select the counting range for U20, and thus the gate time. This operation is outlined in Table 3-1. For example, assume the Resolution selected is 10 Hz. Then RNG 1 will be 1, RNG 2 will be 0, and the U20 will be programmed to count to 100,000. For Channel A mode, the 1 MHz clock is used, so it will take 100,000/1 MHz or 0.1 seconds for U20 to count to 100,000. This 0.1 second time interval is the gate time.

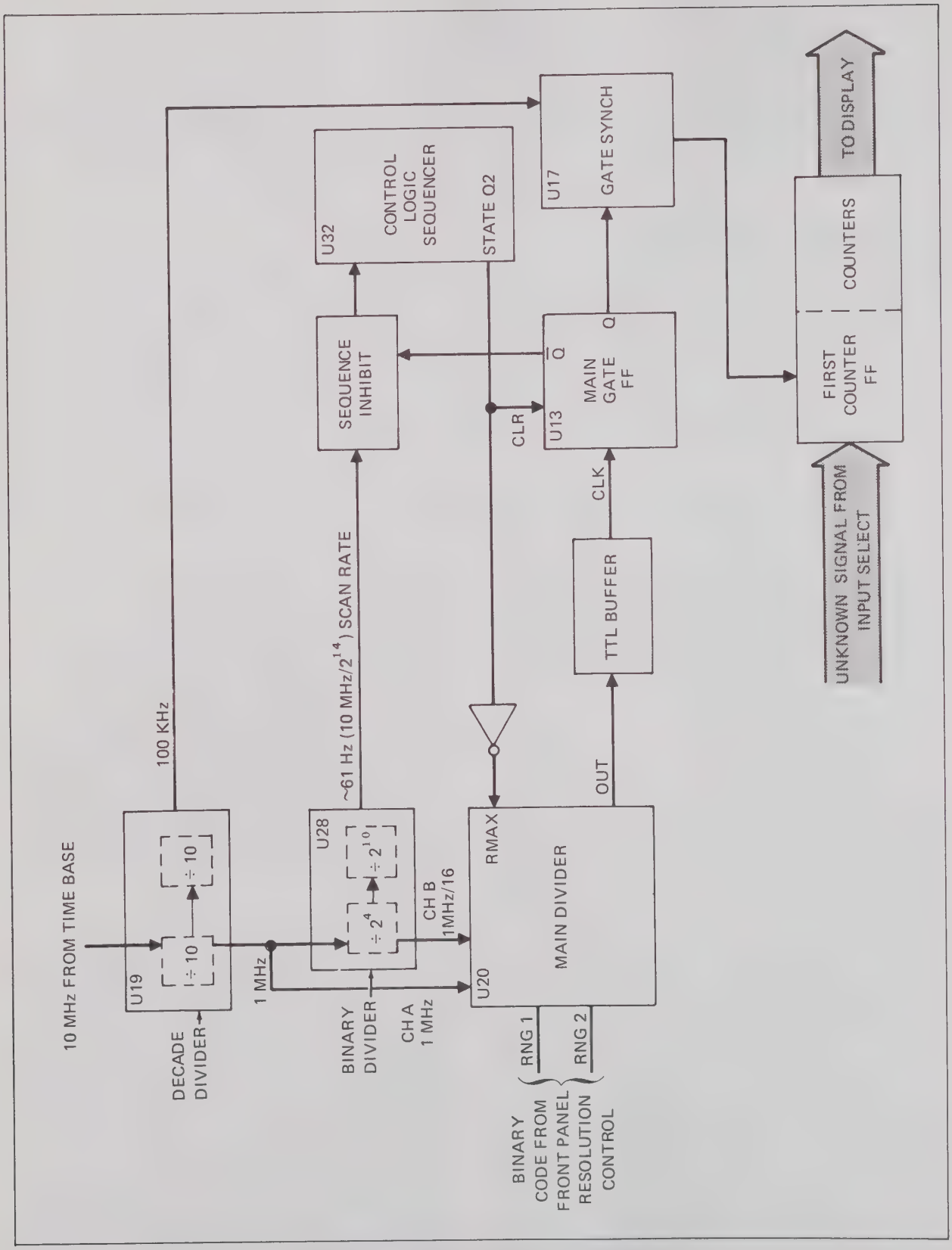


Figure 3-6. Time Base Dividers and First Counter FF

3-74. For Channel B mode, the 1/16 MHz clock is used, so it takes 16 times longer for U20 to count up to 100,000. This means the 10 Hz Resolution gate time is 16 times longer for Channel B than for Channel A, or 1.6 seconds instead of 0.1 second. As can be seen in Table 3-1, the Resolution Multiplier Option -351 does not affect the range or gate times, but instead multiplies very low frequency Channel A signals by 1000, which has the effect of increasing the Resolution by 1000. This is described in detail in the Option -351 information in Section 6 of this manual.

3-75. FIRST COUNTER FF

3-76. The First Counter FF is enabled or disabled by a sequence of events which begins with the Control Logic Sequencer, and involves the Main Divider, the Main Gate FF, and the Gate Synchronizer. The operation of the Control Logic Sequencer is described in detail elsewhere in this section. The timing of the event sequence can be seen in Figure 3-7.

3-77. The event sequence which opens the Main Gate begins with the Q2 pulse from the Control Logic Sequencer. As can be seen in Figure 3-6, Q2 clears the Main Gate FF, and is inverted and applied to the R Max of the Main Divider, U20. When R Max receives a positive pulse, it resets the U20 counters to all 9's. R Max is normally held high, holding the U20 counters at all 9's, but when the inverted (low) Q2 pulse arrives, it releases R Max, allowing the counters to be advanced by the time base clock. On the negative edge of the next clock pulse into U20, the counters advance to all 0's, generating an Out pulse through the TTL buffer (which is needed to raise the U20 MOS signal to TTL) and then on to the Main Gate FF, U13, where it sets the U13 Q output at 1. This is applied to the Gate Synchronizer, which enables the First Counter FF (beginnging the gate time) and allows the unknown signal to pass on to the counters.

3-78. At the same time, the U13 $\overline{Q}$ output goes to 0 and is applied to the Sequence Inhibit (U31, pin 8). The Sequence Inhibit prevents the Sequencer from advancing for the duration of the gate time by holding off the Scan Rate clock. Meanwhile, U20 counts up to the range selected, and when the U20 counters reach their full count and again advance to all 0's, another Out pulse is generated and applied to the Main Gate FF, U13. U13 is a toggle mode, so the Q output toggles to 0. This is applied to the Gate Synchronizer, which disables the First Counter FF (thus ending the gate time) and stops the counting of the unknown input signal. The U13 $\overline{Q}$ output toggles to 1, releasing the Sequence Inhibit, and allowing the Control Logic Sequencer to resume its sequence advance on the next Scan Rate pulse.

3-79. GATE SYNCHRONIZER

3-80. The purpose of the Gate Synchronizer is to restore the time base accuracy to the timing sequence before it reaches the First Counter FF. Since the Main Time Base Divider, U20, is a MOS device, by the time it completes its input clock division and clocks the Main Gate FF, the signal may not be as accurate as the reference time base. The Main Gate FF presents a signal on the D input of the Gate Synchronizer, a D FF, but the Gate Synchronizer does not pass the signal on to the First Counter FF until it is clocked by a 100 kHz signal that comes from the Decade Time Base Divider. This 100 kHz signal has been divided from the 10 MHz reference time base, so time base accuracy is restored to the timing sequence, and the gate times are as precise as the time base signal. This sequence can be seen in Figure 3-7.

Table 3-1. Resolution Control Range and Gate Time

RESOLUTION Setting (Hz) Channels A and B		100	10	1	0.1
RES. MULTIPLIER Setting (Hz) Channel A only		0.1	0.01	0.001	0.0001
RANGE CONTROL	**RNG 1**	0	1	0	1
	RNG 2	0	0	1	1
U20 Main Time Base Division Factor		10^4	10^5	10^6	10^7
GATE TIME (sec.)	**CH A**	0.01	0.1	1	10
	CH B	0.16	1.6	16	160

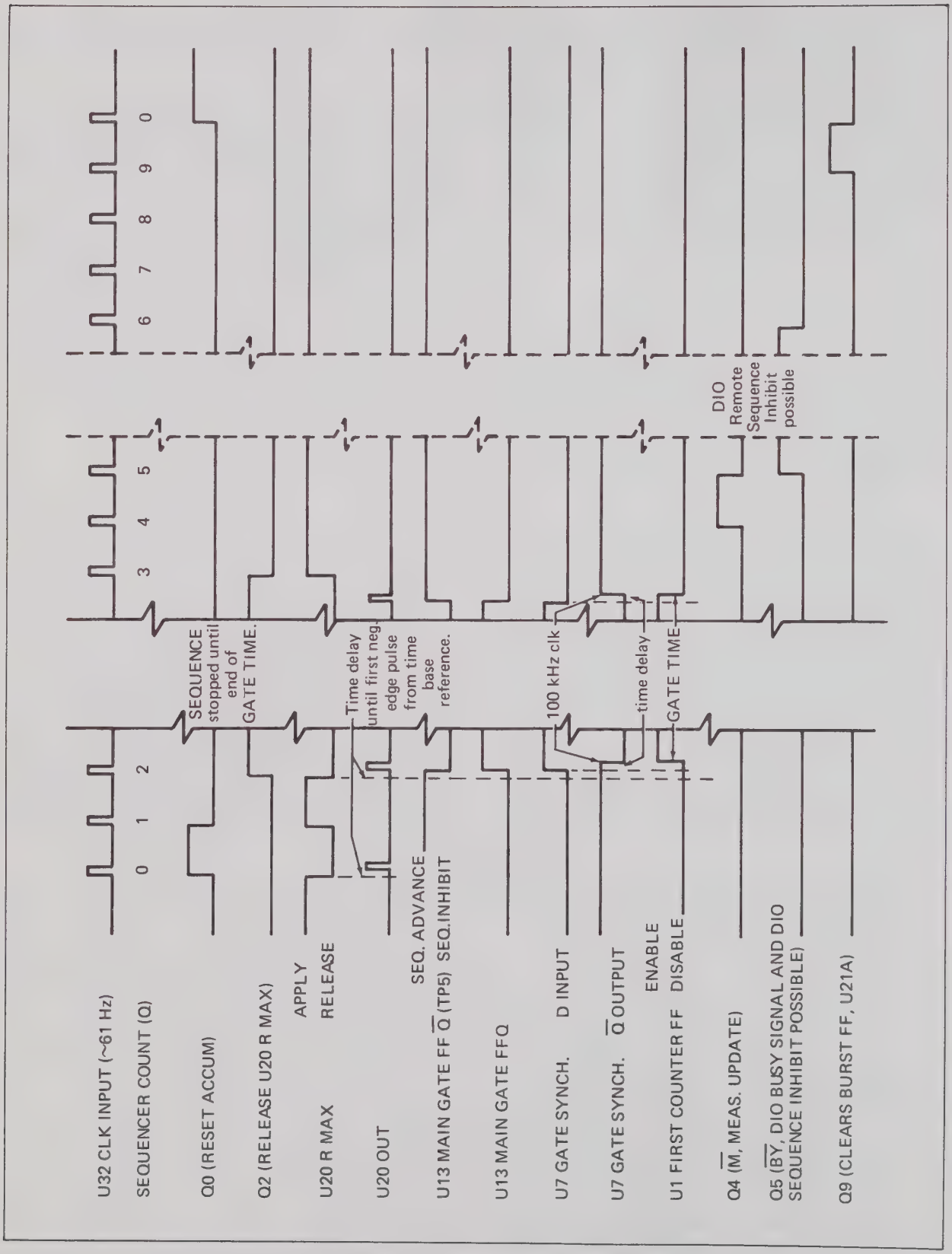

U32 CLK INPUT (~61 Hz)
SEQUENCER COUNT (Q)
0 1 2 3 4 5 6 7 8 9 0
Q0 (RESET ACCUM)
SEQUENCE stopped until end of GATE TIME.
Q2 (RELEASE U20 R MAX)
APPLY
U20 R MAX
RELEASE
Time delay until first neg. edge pulse from time base reference.
U20 OUT
SEQ. ADVANCE
U13 MAIN GATE FF Q̄ (TP5) SEQ.INHIBIT
U13 MAIN GATE FFQ
100 kHz clk
U7 GATE SYNCH. D INPUT
time delay
U7 GATE SYNCH. Q̄ OUTPUT
ENABLE
GATE TIME
U1 FIRST COUNTER FF DISABLE
DIO Remote Sequence Inhibit possible
Q4 (M̄, MEAS. UPDATE)
Q5 (B̄Ȳ, DIO BUSY SIGNAL AND DIO SEQUENCE INHIBIT POSSIBLE)
Q9 (CLEARS BURST FF, U21A)

Figure 3-7. Control Logic Timing

3-81. A time delay is present between the time the D input is received and the next edge of the 100 kHz signal clocks the Gate Synchronizer. This same delay occurs at the trailing edge of the gate time. The effect is to bring the gate signal into time sync with the time base clock, and thus remove the time jitter introduced by the MOS divider chain.

3-82. Control Logic Sequencer

3-83. The Control Logic for 7220A operation is provided by the Control Logic Sequencer, U32, a decade ring counter. U32 operation is outlined in Figure 3-8 and Table 3-2, and a timing diagram is provided in Figure 3-7. The Sequencer advances through a ten-step sequence at a Scan Rate of approximately 61 Hz which is provided by the Binary Time Base Divider. Each of the 10 counts (Q0-Q9) has a separate output, and is normally low except during its respective decimal time slot, when it goes high.

3-84. B ENABLE AND BURST FF

3-85. In order to understand the operation of the Control Logic Sequencer, it is necessary to understand the operation of the BURST Logic, which includes the B Enable and the BURST FF.

3-86. When the Channel B BURST mode is selected by the front panel CH A/CH B switch, the 7220A is designed to wait until a signal input above threshold is present on Channel B, then allow one pass through the measurement cycle from Q0-Q9. During this one cycle, it will count and display the input signal, and then hold that display without update until another burst occurs. This is done by enabling the Clock Enable on the Sequencer (CE, U32, pin 13) for one measurement cycle, and then disabling the Clock Enable.

3-87. Disabling the Clock Enable involves the B Enable ($\overline{BE}$) line, which is tied to the collector of Q6 (see Figure 3-4). When a Channel B input signal above threshold is present, comparator U10 is high, turning on Q6, which puts a low signal on $\overline{BE}$. $\overline{BE}$ is then inverted to BE, and BE is applied to the BURST FF, U21A (see Figure 3-8). The high BE clocks U21A, and the U21A $\overline{Q}$ is low, which enables the Clock Enable and allows the measurement cycle to start, beginning at state Q0. At the end of the measurement cycle, the leading edge of the Q9 pulse clears U21A, which sends the U21A $\overline{Q}$ high, disabling the Clock Enable. No further measurement cycles will take place until BE goes low at the end of the burst and then high again with the next burst.

3-88. As can be seen in Figure 3-8, the Function Control supplies the $\overline{BST}$ line to the Set input of U21A. In the BURST mode, $\overline{BST}$ is low and U21A is not set. But in a non-BURST mode, U21A is set by the high $\overline{BST}$, which causes the low $\overline{Q}$ to enable the Clock Enable all the time, thus allowing continuous measurement cycles to occur in non-BURST modes.

3-89. In order for there to be a measurement in the BURST mode, the BURST signal must be present for a minimum length of time (for gate times see Table 3-1):

Minimum Burst = Gate time + 40 ms

3-90. SEQUENCE INHIBIT

3-91. There are two ways of preventing the U32 Sequencer from advancing. One is by means of the Clock Enable input on U32 and the BURST FF as described earlier. The other is by externally disabling the clock. As can be seen in Figure 3-8, the 61 Hz Scan Rate clock is applied to the Sequence Inhibit function. The Sequence Inhibit also has inputs from the Main Gate FF and the Digital Interface Option -521 (DIO). The Main Gate FF disables the Scan Rate clock in state Q2 during the gate time interval. The DIO can disable the Scan Rate clock in state Q5. The Sequencer will then be held in state Q5 until a Reset is generated. The operation of the Main Gate FF is described in more detail in the previous First Counter FF description. The DIO is described in the section on the Sequence Count Cycle (state Q5) and in Section 6 of this manual.

3-92. SEQUENCE RESET

3-93. The high signal on the U32 Reset input will reset the Sequencer to its first (Q0) count. The Reset may be generated by the front panel Reset control, by remote operation through the Digital Interface Option -521, or by an out-of-lock signal from the Resolution Multiplier Option -351. The operation of the options is described in more detail in Section 6 of this manual.

3-94. SEQUENCE COUNT CYCLE

3-95. The count cycle (states Q0-Q9) for the U32 Sequencer is described in the following paragraphs.

3-96. States Q0 and Q1

3-97. The Sequencer U32 count cycle is outlined in Table 3-2. The count cycle begins with the Q0 state. As shown in Figure 3-8, Q0 does several things: it resets the accumulators, it clears U21B, and it applies a low to the R Max on the Main Time Base Divider, U20, releasing R Max.

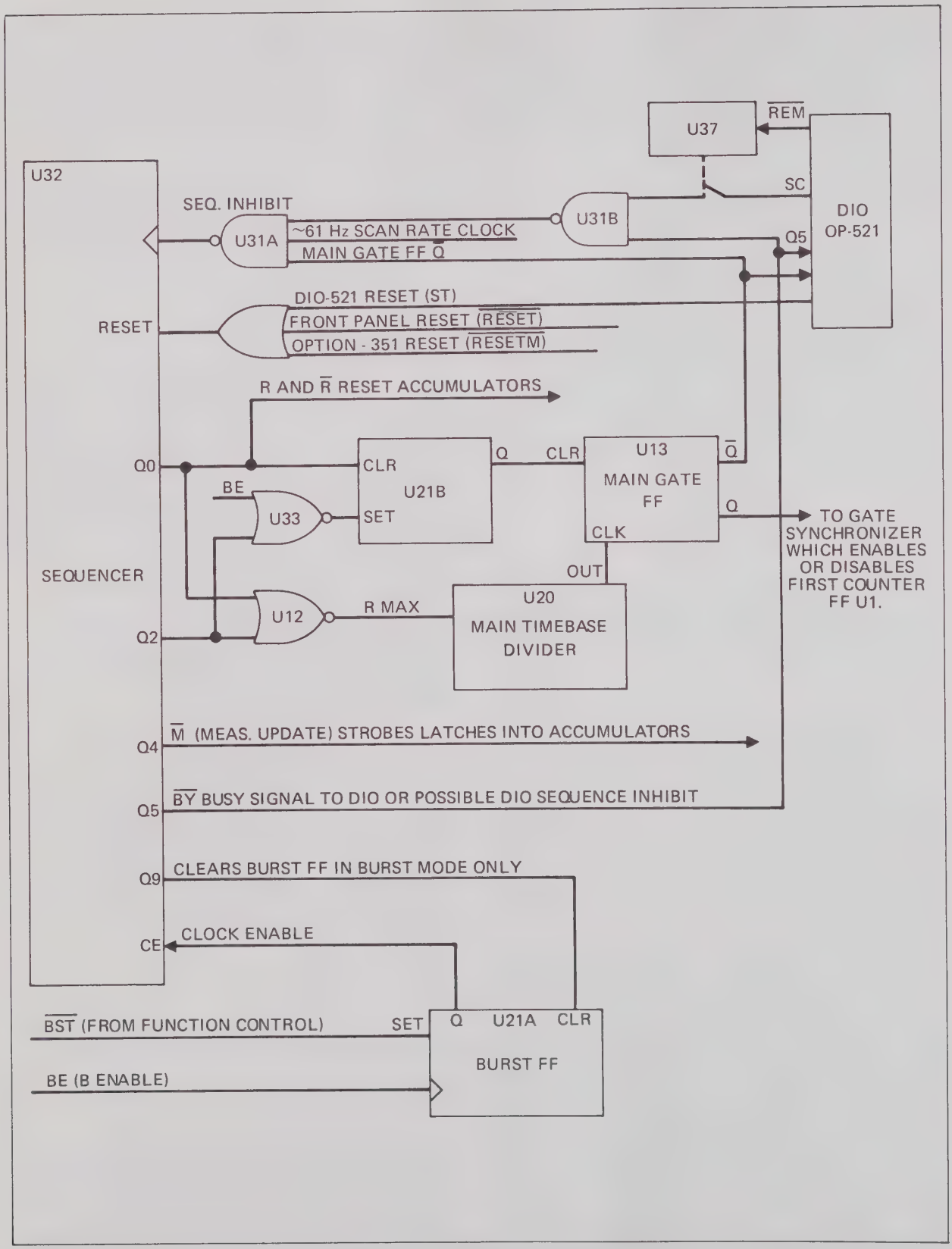


Figure 3-8. 7220A Control Logic

Table 3-2. Sequencer Count Cycle

SEQ. STATE	FUNCTION MODE			
	CHANNEL A	CHANNEL B NON-BURST		CHANNEL B BURST
		with signal above threshold	with signal below threshold	
Q0	Clear Main Gate FF Reset Accumulators Remove U20 R Max (But no gate because Main Gate FF held clear)			
Q1	Nothing happens			
Q2	BE high, so U21B does not set, thus removing U20 R Max, and allowing Main Gate FF to enable U1, beginning gate time. Sequencer inhibited by Main Gate FF $\overline{Q}$ until end of gate time. At end of gate time, Sequencer resumes.		BE low, so U21B sets, which holds Main Gate FF clear and U1 disabled throughout sequence states Q0-Q9.	Same as Channel A
Q3	Nothing happens			
Q4	$\overline{M}$ Measurement Update strobes latches into accumulator, then display		(No measurement, so no display)	
Q5	$\overline{BY}$ Busy signal to DIO Option -521 Also, DIO Remote Sequence Inhibit possible			
Q6-Q8	Nothing happens			
Q9	Nothing happens			Resets BURST FF U21A, which only allows one pass through Q0-Q9.

3-98. A high pulse to R Max will reset U20 counters to all 9's. The counters are held at all 9's as long as R Max is held high. When R Max goes low, or is "released," then the next clock pulse to U20 will advance the U20 counters. As can be seen in Figures 3-7 and 3-8, R Max is released by Q0. This allows the next clock pulse into U20 to advance the counters to all 0's, which generates a pulse on the Out line and clocks the Main Gate FF. However, the Main Gate FF does not respond to the clock signal at this time because it is being held clear by the Q2 output of U32, which is low while Q0 is high. At the next Scan Rate pulse, U32 advances to Q1 which causes U20 to reset to all 9's, but nothing else happens during Q1.

3-99. State Q2

3-100. The First Counter FF can be enabled or disabled during the Q2 state. As shown in Table 3-2, the events that occur during Q2 depend in part on the Function control mode selected. If the Channel B non-BURST mode is selected, the Channel B input signal determines whether or not the gate opens. There are two possible cases. In the first case, if an input signal below threshold is detected by the Threshold Detect Circuit (as described in the section on Channel B signal conditioners), then BE (B Enable) goes low and U21B will set. This will hold the Main Gate FF clear, so that the First Counter FF will not be enabled and no measurement takes place.

3-101. In the second case, if an input signal above threshold is detected by the Threshold Detect Circuit, then BE goes high and U21B will be reset by Q0. As shown in Figure 3-8, Q2 will release R Max. The next clock pulse into U20 turns the counters over to all 0's, generating an Out pulse which clocks the Main Gate FF, U13. This sends U13 $\overline{Q}$ low, inhibiting the Sequencer, and sends U13 Q high, which is presented at the D input to the Gate Synchronizer, U7. The next 100 kHz clock pulse into U7 clocks U7, which enables the First Counter FF, U1, beginning the gate time, and allows the input signal to be counted. U20 counts up to the range selected by the RESOLUTION setting, and again turns over to all 0's,

generating an Out pulse which clocks U13. The Q output of U13 goes low, and is presented at the U7 D input. At the next 100 kHz clock pulse, U7 $\overline{Q}$ goes high and disables the First Counter FF, U1, ending the gate time. Meanwhile, U13 $\overline{Q}$ goes high and removes the Sequence Inhibit, allowing the next 61 Hz pulse to advance the Sequencer to state Q3.

3-102. As shown in Table 3-2, when Channel B BURST and Channel A are selected, the Sequencer follows the same steps as when the Channel B non-BURST is selected and an input signal above threshold is detected. Channel A follows these steps because diode CR7 pulls the $\overline{BE}$ line low, which makes it look like the Channel B non-BURST mode with an input signal above threshold.

3-103. States Q3 and Q4

3-104. Nothing happens in the Q3 state. In the Q4 state, the $\overline{M}$ Measurement Update is generated, which strobes the count into the latches and allows the count to be displayed.

3-105. State Q5

3-106. In the Q5 state, a busy signal is sent to the DIO Option -521 (if installed), which tells the remote interface that a measurement cycle is in progress. As mentioned in the section about the Sequence Inhibit, the Sequencer can also be held in state Q5 by commands from the DIO. Figure 3-8 shows how this works. When the $\overline{REM}$ line is true, the counter's measurement cycle can be controlled by an external controller operating through the -522 and -521 Options (see Section 6) and controlling the SC line.

3-107. When $\overline{REM}$ is low and SC is high, the Sequencer is allowed to go through one measurement cycle beginning at state Q0. When state Q5 occurs and is applied to U31B along with the high SC, the Sequence Inhibit prevents the Scan Rate clock from advancing the Sequencer. The Sequencer remains in state Q5 until a Reset (ST) command is generated through the DIO. When $\overline{REM}$ is low and SC is low, the Sequencer will pass through the measurement cycle continually. This is because the low SC line does not allow the Q5 to remove the Scan Rate clock from the Sequencer. When $\overline{REM}$ is high, the switch U37 grounds the SC line, thus preventing Q5 from inhibiting the Scan Rate clock from the Sequencer. The Sequencer will pass through the measurement cycle continually if not in the BURST mode.

3-108. States Q6 Through Q9

3-109. Nothing happens in states Q6, Q7, and Q8. As mentioned before, when the Channel B BURST mode is selected, state Q9 will reset the BURST FF. This allows only one Q0-Q9 measurement cycle to take place. The Reset command must be generated to allow another measurement cycle to take place in the BURST mode.

3-110. Nine Digit Count and Display

3-111. The 7220A nine digit display capacity is provided by nine decade counters, with appropriate latch, multiplex, driver and display circuitry. Most of the counter, latch and multiplexing capability is provided by U15. As can be seen from Figure 3-9, U15 provides six of the nine decade counters, as well as the latches and multiplexing for the first eight digits. The other three decade counters are external to U15, and the ninth (most significant) digit has its own counter, latch, multiplexer, and control logic to insert the ninth digit information onto the bus lines to the digit and LED segment drivers.

3-112. COUNTERS AND LATCHES

3-113. The counter which supplies the data for the least significant digit is actually composed of four J-K flip-flops. The first Counter FF, U1, a very high speed ECL J-K FF, also serves the gating function for the 7220A. Its clock input is the unknown signal to be measured, and it is enabled or disabled by the Gate Synchronizer, U7, via the J and K inputs. The First Counter FF is also described in the section on Time Base Dividers.

3-114. When the gate signal enables U1, its Q and $\overline{Q}$ outputs pass the divided-by-two signal to the transistor differential pair, Q7 and Q8. Transistors Q7 and Q8 translate the U1 ECL level signal to TTL, and pass it to the next three J-K FF's, which collectively divide the signal by five and provide the rest of the BCD data for the least significant digit. The carry of the last FF passes to the next BCD decade counter which provides BCD data for the second least significant digit. As shown in Figure 3-9, the first two digits of BCD data pass into U15 to be latched. The BCD decade counters for the third through the eighth digits are contained in U15. The carry from the eighth digit counter passes outside U15 to the ninth (most significant) digit BCD counter. When U15 and the ninth digit latch receive the $\overline{M}$ Measurement Update pulse from the Control Logic Sequencer, the eight internal latches of U15 and the ninth digit latch open and receive the BCD data from the counters.

3-115. MULTIPLEXING AND DISPLAY

3-116. The timing for the digit strobing and the LED segment BCD data strobing is outlined in Figure 3-10. During display operation, the Buffer/LED drivers for the nine digits are powered one at a time, beginning with the most significant digit, DS9, on through to the least significant digit, DS1. The multiplexer follows the same sequence to select the proper latch, and presents the BCD data to the BCD-to-Seven-Segment Decoder/Driver,

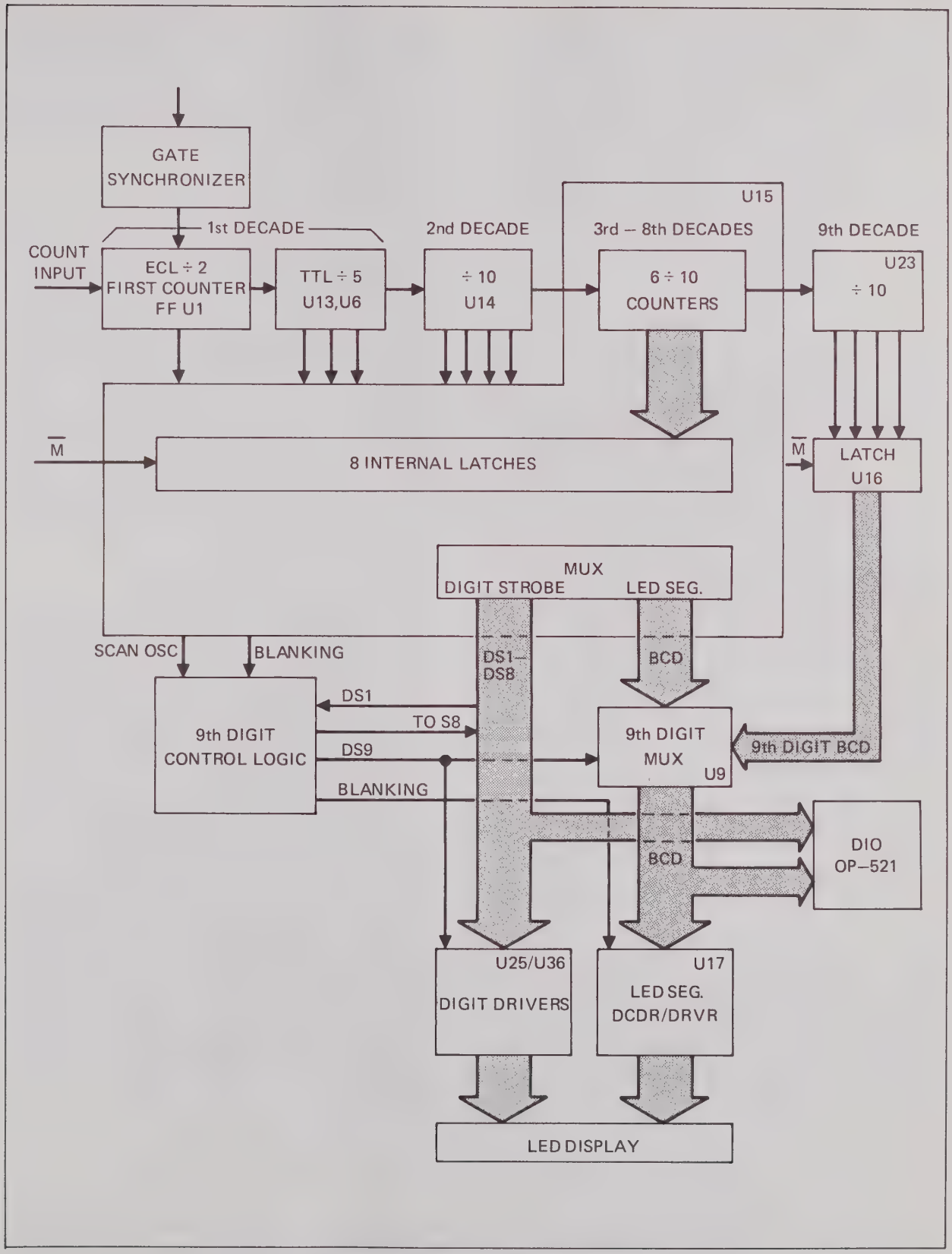


Figure 3-9. Counter and Display Logic

which selects the LED segments required to configure the proper value for that digit to display. The LED segment bus line of the Decoder/Driver is connected to all nine digits in the display, but the only digit that lights up is the one selected and powered at that time by its digit strobe.

3-117. As shown in Figure 3-10, the length of the digit strobe is slightly less than the length of time the BCD data is presented. Both the leading and trailing edge of the data strobe are protected in this way to ensure that the BCD data is displayed by the proper digit strobe.

3-118. U15 Multiplexing

3-119. Multiplexer U15 provides the digit strobing and BCD data multiplexing for digits eight (the second most significant) through one (the least significant). The ninth digit strobing and multiplexing is provided by separate circuitry, and is described later under Ninth Digit Logic. The strobing and multiplexing of U15 is accomplished by an internal scan counter. The scan counter is driven by an internal oscillator whose frequency is determined by the value of capacitor C30 and resistor R61. The oscillator frequency is approximately 1.2 kHz. As can be seen in Figure 3-10, the scan counter advances on the negative edge of the oscillator signal, and it steps through the digits in sequence, from DS8 to DS1.

3-120. Ninth Digit Logic

3-122. The purpose of the Ninth Digit Control Logic, which is shown in Figure 3-11, is to generate the ninth digit strobe (DS9, the most significant digit), and to insert DS9 and the ninth digit BCD data into the U15 scan sequence. The control logic receives input from the oscillator, blanking, and DS1 of U15. At the end of DS1, the control logic generates DS9, and SR, the Scan Reset. DS9 is applied to the Buffer/LED Driver, and also to the Ninth Digit Multiplexer, which routes the BCD data from the ninth digit latch to the LED segment Driver.

3-122. SR forces the Scan Counter of U15 to the eighth digit state, where it is held until SR is released. During SR, the multiplexing function of U15 is held off, although its internal oscillator continues to run. U15 is also held in state DS8, but DS8 is not desired at this time, since DS9 is being strobed. To prevent DS8 from being applied to the Buffer/LED Driver, SR is inverted and tied to DS8 to remove it (in Figure 3-11, S8 is the U15 output at pin 2, while DS8 is the effective digit strobe seen by the Buffer/LED Driver). The Ninth Digit Control Logic holds DS9 and SR for one period of the oscillator, then releases them. Now U15 resumes its scan sequence, beginning with DS8, and continues through the sequence until the completion of DS1, when the Ninth Digit Control Logic again inserts DS9.

3-123. Display Blanking Logic

3-124. The purpose of the Display Blanking Logic is to suppress all but one leading zero occurring in the display. The Display Blanking Logic operation is outlined in Figure 3-12. Flip-flop U35A examines the nine digits from the left (Digit 9, the MSD) to the right (Digit 1, the LSD), and will suppress all but one leading zero. U35A is used as an R-S FF. While it is set, it blanks U17, the LED Segment Driver, and will continue to blank U17 until it is cleared. It is set during DS9 and will be cleared by one of two things: (1) Any non-zero BCD data preceding the decimal point; 2) The BL (blanking) output of U15 if a zero is to precede the decimal point. If a clear input to U35A occurs during DS9, it will override the set input and allow display of DS9.

3-125. Decimal Point Placement

3-126. The purpose of the Decimal Point Placement Logic is to get the decimal point turned on during the proper digit strobe time so it appears in the correct place in the display. Depending on its position, the front panel RESOLUTION switch puts +5V on one of the lines DP1, DP2, DP3, or DP4. U38 is an analog switch which connects any one of these 4 lines (or none of them) to the base of the decimal point driver, Q9. This is shown in Figure 3-13. The digital multiplexer U26 connects one of two possible sets of digit strobes to the control lines of analog switch U38. One combination of digit strobes is connected when using the Resolution Multiplier Option -351, and another is selected when in any of the other Functions, giving the two sets of possible decimal point locations. As digit strobe pulses appear at the analog switch control inputs, C1-C4, the corresponding input DP1-DP4 is connected to the output. When the input line with +5V on it is connected to the output, the decimal point lights in the correct position of the display. Table 3-3 presents a list of Resolution settings and the corresponding Digit Strobes during which the decimal points appear.

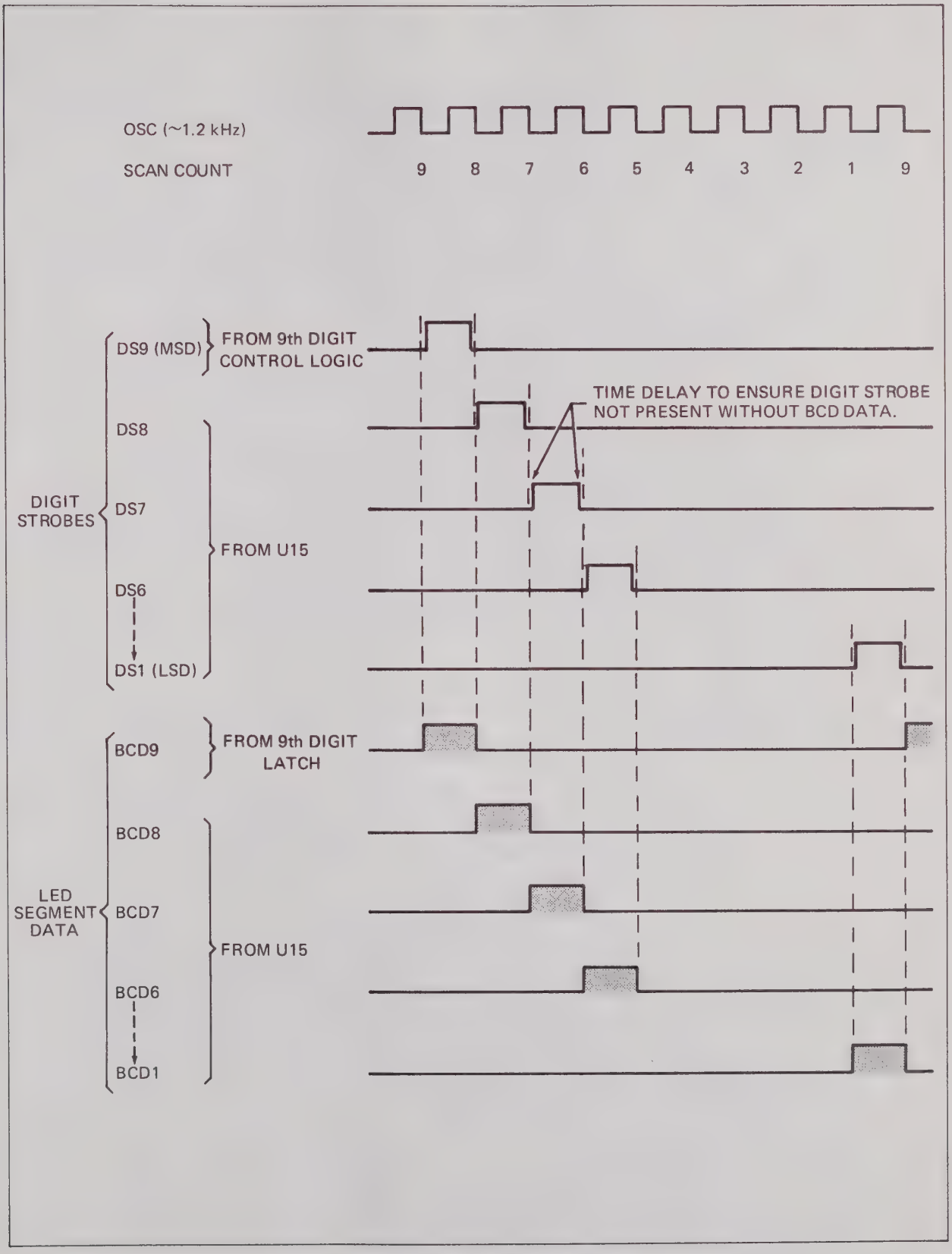


Figure 3-10. Strobing and Multiplex Timing

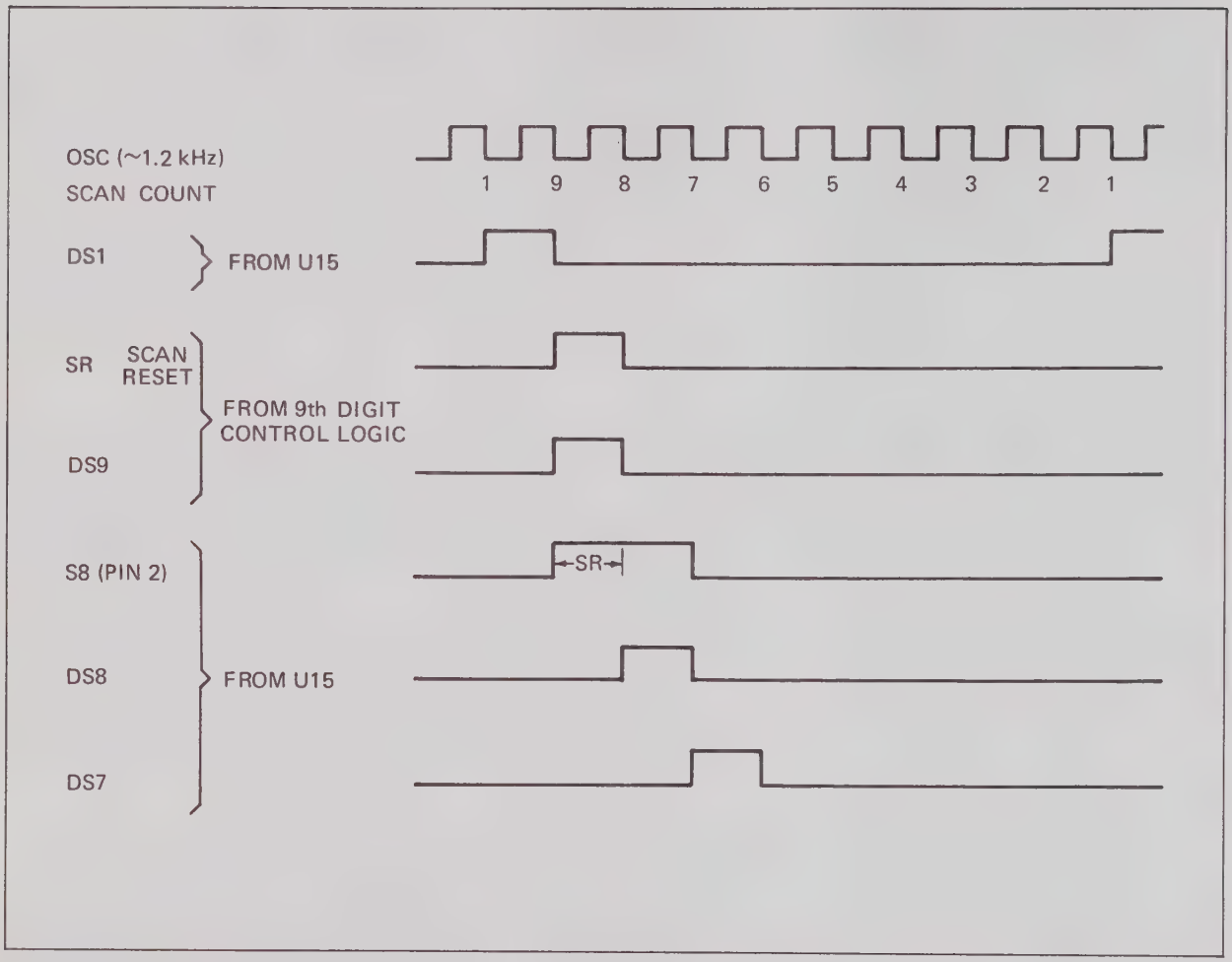


Figure 3-11. Ninth Digit Control Logic

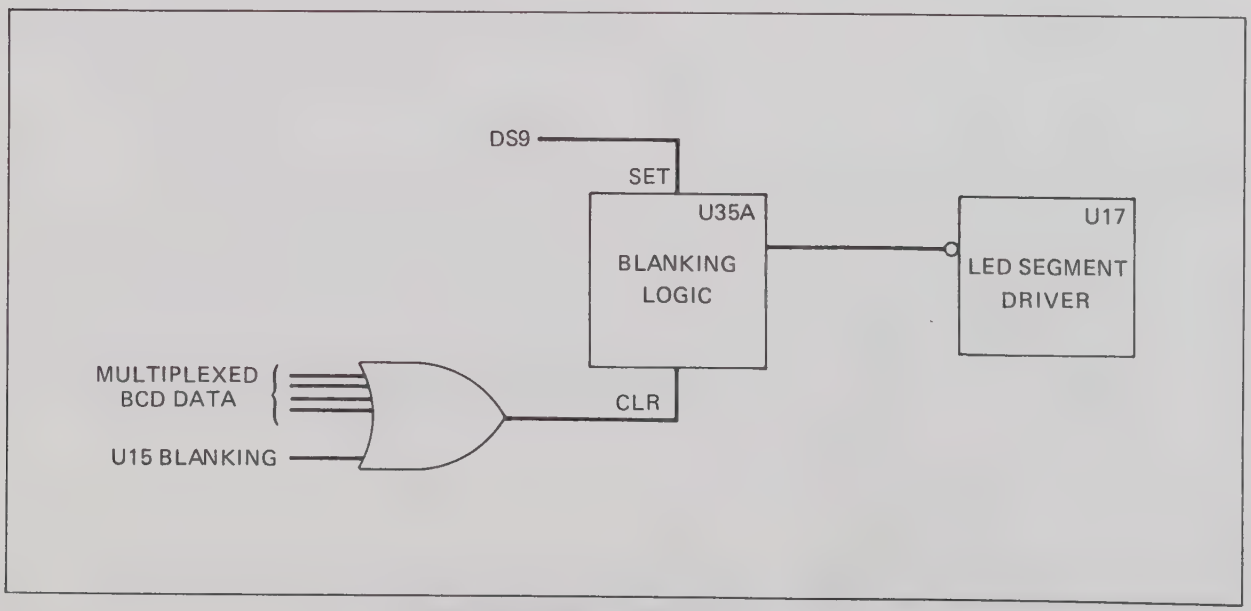


Figure 3-12. Display Blanking Logic

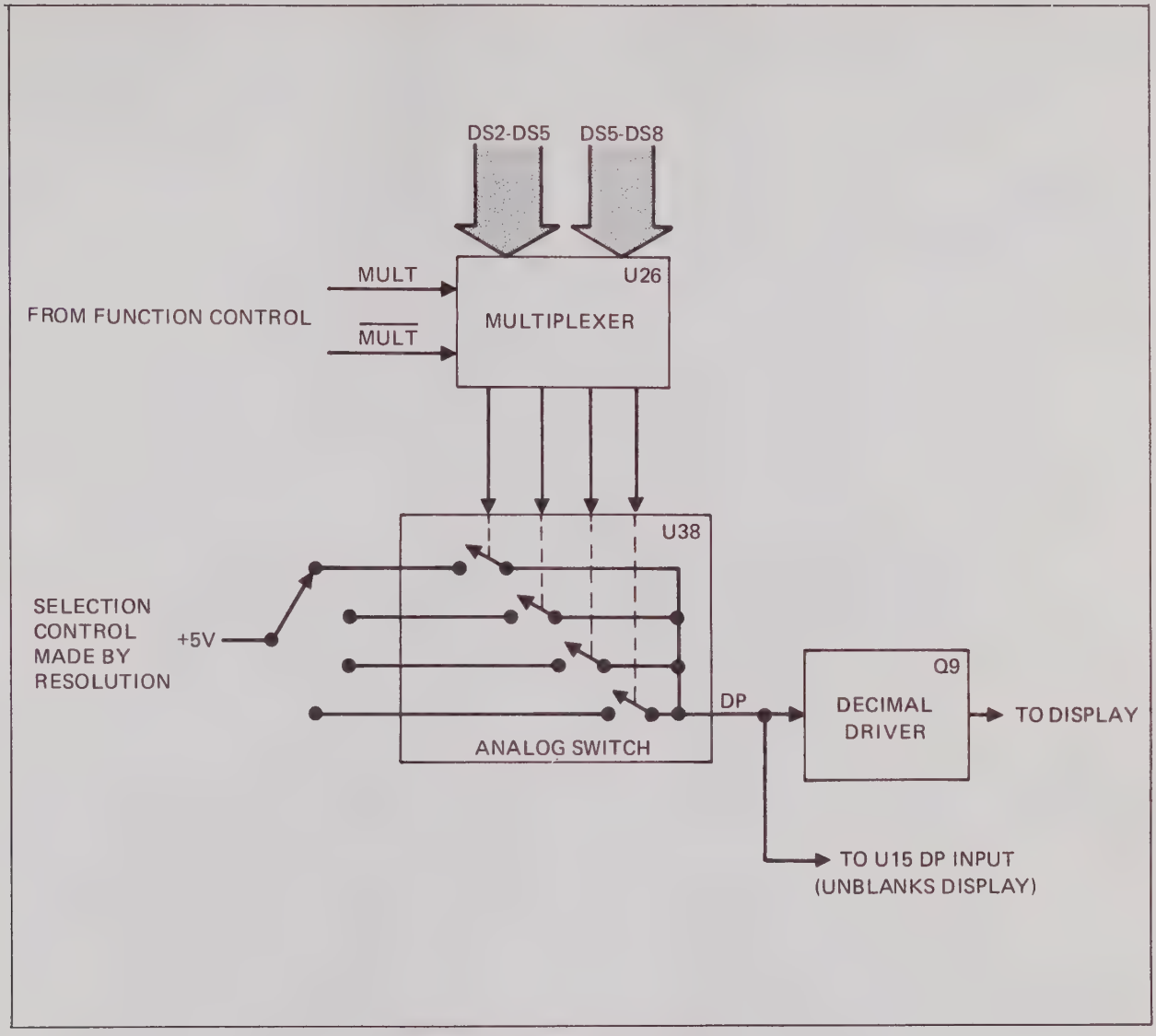


Figure 3-13. Decimal Point Selection

Table 3-3. Decimal Point Digit Strobes

RESOLUTION	DIGIT STROBE	RESOLUTION	DIGIT STROBE
Without Resolution Multiplier		With Resolution Multiplier	
MULT = 0		MULT = 1	
$\overline{\text{MULT}}$ = 1		$\overline{\text{MULT}}$ = 0	
100 Hz	DS5	0.1 Hz	DS2
10 Hz	DS6	0.01 Hz	DS3
1 Hz	DS7	0.001 Hz	DS4
0.1 Hz	DS8	0.0001 Hz	DS5

Section 4
Maintenance

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING OTHER THAN THAT CONTAINED IN THE OPERATING INSTRUCTIONS UNLESS YOU ARE QUALIFIED TO DO SO.

4-1. INTRODUCTION

4-2. This section of the manual provides information concerning warranty, general maintenance, performance tests, calibration and troubleshooting for the 7220A Frequency Counter. Test Equipment recommended for performance tests, calibration, and troubleshooting is listed in Table 4-1. If the recommended equipment is not available, equipment with equivalent specifications may be used.

4-3. SERVICE INFORMATION

4-4. The instrument is covered by a warranty for a period of 1 year from the time of delivery to the original purchaser. The WARRANTY is located on the back of the title page of this manual.

4-5. Factory authorized calibration and service for each Fluke product is available at various world wide locations. A complete list of these service centers is included in Section 7 of this manual. If requested, an estimate will be provided to the customer before any work is begun on instruments that are beyond the warranty period.

4-6. GENERAL MAINTENANCE

NOTE

To avoid contaminating the pcbs with oil from the fingers, handle the pcbs by their edges or wear gloves. If a pcb does become contaminated, refer to the cleaning procedure.

4-7. Disassembly

4-8. To disassemble the instrument, use the following procedure:

1. Press the power switch to STBY, and remove the line power cord.

2. On the case bottom, remove the six securing screws. Two of these screws will be found in the middle of the case along the side, under the latches. To access either middle screw, as shown in Figure 4-1, alternately push the two latching rails away from the triangular stop. Pull the latch out far enough to reveal and remove the screws.

NOTE

Do not hold the case bottom while lifting off the case top, as this could result in damage to the Main PCB. The Main PCB is still attached to the case bottom by a screw in the middle of the board.

3. In the front, press down on the BNC input connectors, while gently pulling up on the case top lip. In the rear, press down on the BNC connectors, while pulling up on the top case lip. Alternating between front and back panels, pry the case top free from the rest of the instrument.

Table 4-1. Required Test Equipment

EQUIPMENT TYPE	REQUIRED SPECIFICATIONS	RECOMMENDED TYPE
Oscilloscope	Dual trace, DC-200 MHz wide band	Tektronix 475
High Frequency Signal Generator	1-1300 MHz at a level of 1V rms. Time base 1 x 10^{-8} per day.	HP 8660
Low Frequency Signal Generator	5 Hz-10 MHz at a level of 1V rms. Time base 1 x 10^{-8} per day.	John Fluke 6011A
Variable AC Power Supply	Variable voltage from 0-250V ac.	Variac
Frequency and Time Standard	Aging rate of 5 x 10^{-10} per day or less.	HP 5061A
Digital Multimeter (DMM)	AC volts 0-250V ac. DC volts 0-20V dc with accuracy ±0.1% of reading ±1 digit. Resistance 0 - infinity.	John Fluke 8020A
Variable RF Attenuator	0-50 dB over 0-1500 MHz range.	Weinschel AD-117A
RF Voltmeter	125 MHz, 4 mV rms - 5V rms.	Boonton 92-BD
50 Ohm Terminators (2)	Impedance match the 7220A.	GR 874
BNC Tee		
Oscilloscope Probe	X10, DC-125 MHz	Tektronix P6055

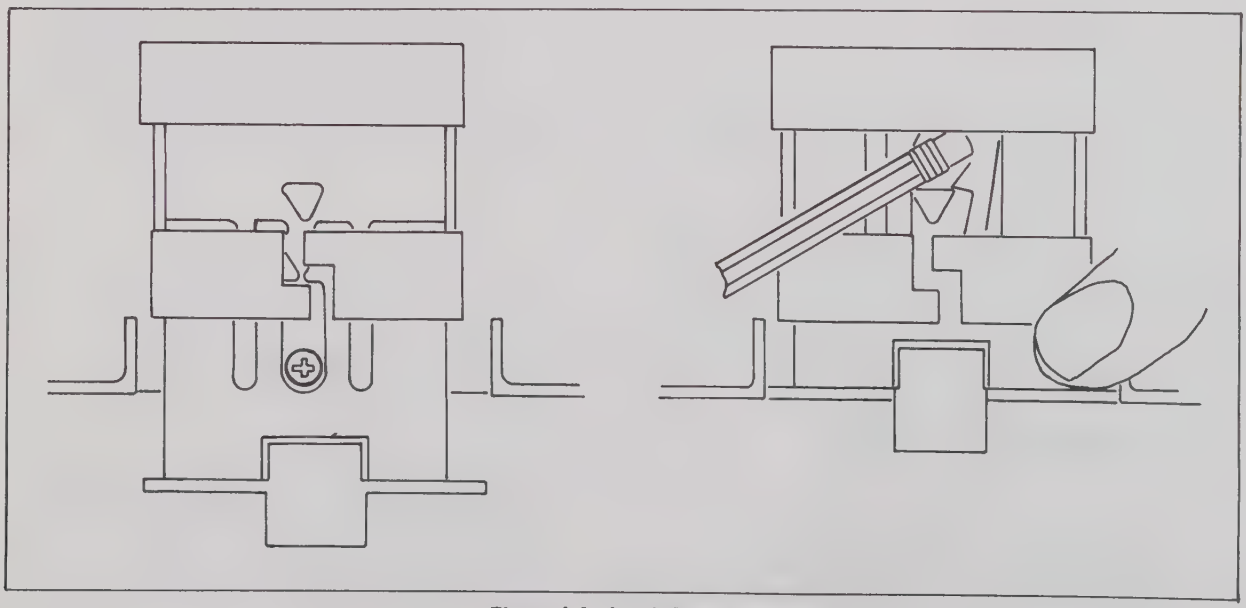


Figure 4-1. Latch Removal

NOTE

For most test and calibration procedures, stop at this step. If continuing beyond this step, take special note of Step 4.

4. Remove the single screw at the middle of the Main PCB, and separate the case bottom.

5. To remove the Front Panel Assembly (A2) from the Main PCB Assembly, first pull off the following switch buttons in the lower left corner of the front panel:

a. ON - STBY (green)

b. BAT - LINE (white)

c. RESET (blue)

6. Gently lift the Front Panel Assembly away from its 40 square-pin connector (left) and guide pin and 3 square pins (right). The Channel B input coax cable may be disconnected from the Main PCB by pulling its connector straight up from the Main PCB.

NOTE

Avoid bending any of the connector square pins on the Main PCB. After removing the Front Panel Assembly, examine the pins and straighten any that are bent before reconnecting the Front Panel Assembly.

7. If it is necessary to separate the Front Panel PCB from the front panel, remove the following items:

a. Front panel Channel A BNC nut.

b. Front panel variable attenuator knob.

c. Mounting screw by the power switch holes (accessible from rear of PCB).

d. Mounting screw by the variable attenuator trimpot R12 (accessible from rear of PCB).

NOTE

When the front panel is separated from the Front Panel PCB, there are no stops to prevent the slide switch actuators from moving beyond their proper position. Care must be taken to keep them in position.

8. To remove the rear panel, first remove the top and bottom case covers. If the Option -521 PCB has been installed, it must be detached from its Main PCB connector before the rear panel can be removed. Remove the two rear panel mounting screws that attach the heat sink to the Main PCB (see Figure 4-8). Carefully pull the bottom of the rear panel outward so it can clear the REF switch, and firmly pull the rear panel straight up, pulling the leads of the 3 regulators (U40, U41 and U42) out of their sockets.

9. Refer to Section 6 of this manual when removing any optional assemblies.

4-9. Reassembly

4-10. For reassembly, the disassembly procedures can generally be followed in reverse order. Keep the following considerations in mind:

1. When reinstalling the Front Panel Assembly, care should be taken not to bend the connector square pins, and to align the three square pins on the right side so they correctly engage their sockets.

2. When reinstalling the rear panel, care should be taken not to bend the regulator leads. Also, be sure to firmly tighten the mounting screws that connect the heat sink to the Main PCB. The regulator leads will not be firmly seated unless these screws are firmly tightened.

3. When reconnecting the top and bottom case halves, ensure that the Front and Rear Panels fit into their appropriate grooves in the case top half. Slide the top half into place uniformly. Firmly squeeze top and bottom together (at front and rear), and reinstall the six securing screws.

NOTE

Proper RFI shielding depends on top and bottom case halves being securely mated.

4-11. Input Power

4-12. Input line voltage is selected by positioning the two switches in the right rear corner of the Main PCB. Each switch (S4 and S5) shows a position identifying red or white dot. Line voltage settings identified by dot color are presented in Figure 4-7. Factory line voltage settings of 100V, 120V, 220V, or 240V are identified on the rear panel of the instrument. When changing the line voltage, refer to the Power Supply Adjustment under the Calibration Adjustments section.

4-13. Fuse Replacement

WARNING

BEFORE ATTEMPTING FUSE REPLACEMENT, REMOVE LINE POWER FROM THE INSTRUMENT.

4-14. The 7220A line power fuse F1 is accessible on the rear panel, and fuse requirements are marked on the rear panel beside the fuse holder. A 1/4A (slo-blo MDL Fluke #166306) fuse is required for line inputs of 100V or 120V, and a 1/8A (slo-blo MDL Fluke #166488) fuse is required for line inputs of 220V or 240V. If fuse replacement is necessary, disconnect the 7220A from line power and remove the fuse cap and fuse (twist the fuse cap ccw using a screwdriver), and replace the fuse.

4-15. The Channel B input is fuse-protected by fuse F2, a 2/10A plug-in fuse (Fluke #370577) which is plugged into the Main PCB next to the Channel B coaxial cable. There is also a spare Channel B fuse, F3, which is plugged into the Main PCB in front of the transformer T1. Both of these fuse locations can be seen in Figure 4-8. To remove F2 or F3, remove the top and bottom case halves from the Main PCB. Firmly work the fuse straight out from its socket.

4-16. Cleaning

4-17. Clean the instrument periodically to remove dust, grease and other contamination. Use the following procedure:

CAUTION

Do not use aromatic hydrocarbons or chlorinated solvents for cleaning. They will react adversely with plastic materials used in manufacture of the instrument.

1. Clean the front panel and case with soft cloth dampened with a mild solution of detergent and water.

2. Clean the surface of the PCBs using clean, dry air at low pressure (=20 psi). If grease is encountered, spray with Freon T.F. Degreaser or anhydrous alcohol and remove grime with clean, dry air at low pressure.

4-18. PERFORMANCE CHECKS

4-19. The Performance Checks are used to compare the performance of the instrument with the Specifications given in Section 1. The Performance Checks are recommended as an acceptance test when the unit is first received, and later as a calibration procedure to verify instrument accuracy at the scheduled calibration periods. It is also useful as an aid in troubleshooting. All of the Performance Checks other than the Time Base Check should be performed every 90 days. The Time Base Check should be performed as often as the desired Specification requires. Should the instrument fail any portion of the Performance Checks, calibration and/or repair may be needed. Refer to Table 4-1 when specific test equipment is required.

4-20. Initial Set-up

4-21. The following controls should be in the indicated positions prior to conducting any Performance Check.

1. On the rear panel of the 7220A, set the REF to INT. The line power cord should be connected to line power.

2. On the front panel of the 7220A, set the controls as follows:

ON/STBY	ON
BAT/LINE	LINE
RESOLUTION	10 Hz
CH A/CH B	CHK
VAR. ATTENUATION	Fully CCW
STEP ATTENUATION	X1

3. Set CH A/CH B to CHK. Verify the display as listed in Table 4-2.

4. Observe that the display resets each time the RESOLUTION or CH A/CH B switches are changed.

To verify the operation of the RESOLUTION MULTIPLIER mode, see the Performance Check in Section 6.

Table 4-2. Display Check

FUNCTION	RESOLUTION	DIGIT DISPLAY
125 MHz	100 Hz	0.0000
125 MHz	10 Hz	0.00000
125 MHz	1 Hz	0.000000
125 MHz	0.1 Hz	0.0000000
CHK	100 Hz	10.0000
CHK	10 Hz	10.00000
CHK	1 Hz	10.000000
CHK	0.1 Hz	10.0000000

4-22. Time Base and Time Base Output Check

4-23. Use the following procedure to check the accuracy of the time base and the operation of the INT REF OUT circuitry:

NOTE

To check the time base, the source of the input signal must have an accuracy greater than that of the time base. Refer to Table 4-3 for the maximum allowable time base error, and refer to Table 4-1 for the recommended Frequency and Time Standard.

1. Set the 7220A controls as listed in the Initial Set-up except for the following changes.

RESOLUTION	0.1 Hz
CH A/CH B	125 MHz

2. Connect a 10 MHz Frequency standard to the Channel A input terminal.

3. Verify that the display reading on the 7220A is 10 MHz ± the maximum allowable count error. Table 4-3 lists the maximum allowable count error at 10 MHz (and 0.1 Hz resolution) for each of the four time bases available for use with the instrument. The maximum allowable count error can be computed for any input signal by multiplying the frequency of the input signal by the total time base accuracy (given in Table 4-3) and adding the ±1 count error to the product.

4. Connect the oscilloscope to the REF OUT terminal on the 7220A rear panel through as short a length of RG-58 cable as possible. The oscilloscope end of the test cable must have a 50 ohm termination. Be sure the 7220A rear panel REF is set to INT.

5. Verify that the signal displayed on the oscilloscope is 10 MHz.

4-24. Channel A Input Sensitivity Check

4-25. Use the following procedure to verify that Channel A input sensitivity lies within the Specifications given in Section 1:

1. Set the 7220A controls as listed under Initial Set-up except for the following changes:

Rear panel:	REF	EXT
Front panel:	CH A/CH B	125 MHz

2. Connect the 7220A and test equipment as illustrated in Figure 4-2.

3. Verify that correct readings are displayed for the input signals and voltage levels listed in Table 4-4.

NOTE

The stability of counter readings will be no greater than the stability of the Signal Generator.

4. Set the 7220A RESOLUTION to 0.1 Hz. Apply a Channel A input signal of 125 MHz at 100 mV rms. Following a 10 second gate time, verify that the display is 25 MHz and that the OVFL LED is lit.

Table 4-3. Time Base Performance Check

TIME BASE TYPE	FREE AIR	1 PPM TCXO OPTION -111	OVEN OPTION -131	OVEN OPTION -132
Total Time Base Accuracy*	$\pm 56 \times 10^{-7}$	$\pm 15.0 \times 10^{-7}$	$\pm 2.2 \times 10^{-7}$	$\pm 8.4 \times 10^{-8}$
Maximum Allowable Deviation** (with 10 MHz input)	±56.1 Hz	±15.1 Hz	±2.3 Hz	±0.9 Hz

**Includes aging rate per month, temperature effects, line voltage variation.*

***Allowable deviation in Hz is found by multiplying the input frequency (10 MHz in this case) by the total accuracy, and adding 1 count error. These figures apply when in 0.1 Hz resolution.*

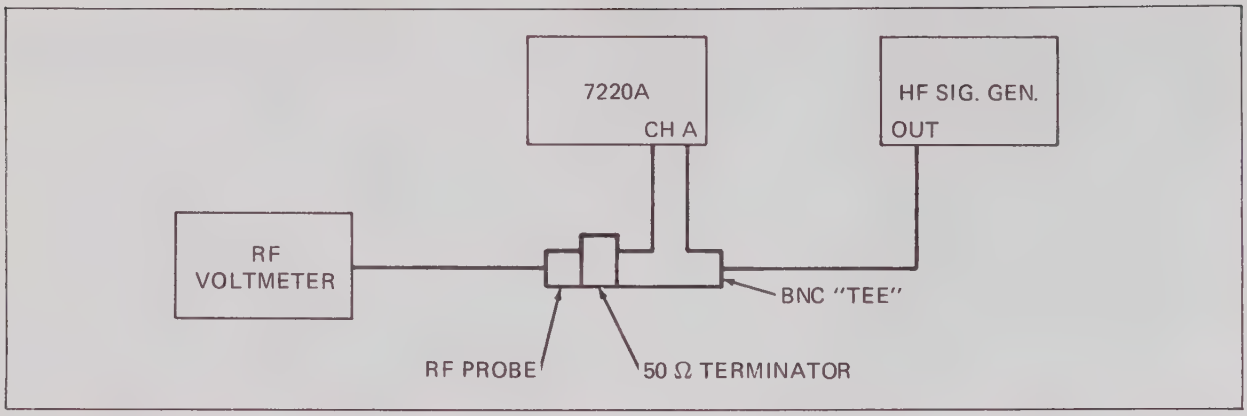


Figure 4-2. Channel A High Frequency Input Sensitivity Check

Table 4-4. Channel A High Frequency Input Sensitivity

INPUT SIGNAL	VOLTAGE (rms)
50 MHz	10 mV
100 MHz	15 mV
125 MHz	25 mV

Table 4-5. Channel A Low Frequency Input Sensitivity

RESOLUTION	INPUT SIGNAL	VOLTAGE (rms)
1 Hz	10 Hz	10 mV
1 Hz	1000 Hz	10 mV
10 Hz	50 kHz	10 mV
10 Hz	1 MHz	10 mV
10 Hz	10 MHz	10 mV

5. Set the 7220A RESOLUTION to 10 Hz. Apply a Channel A input signal of 125 MHz at 25 mV rms. While varying the input signal voltage level from 25 mV rms to 1 V rms, observe a correct display of 125 MHz at all voltage levels.

6. Disconnect the High Frequency Signal Generator and RF voltmeter from the 7220A, and connect the Low Frequency Signal Generator as shown in Figure 4-3.

7. Verify that correct readings are displayed for the 7220A RESOLUTION settings, input signals and voltage levels listed in Table 4-5.

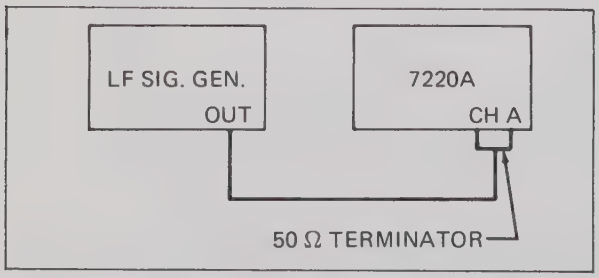


Figure 4-3. Channel A Low Frequency, Filter, and Attenulation Check

4-26. Channel A Filter Check

4-27. Use the following procedure to verify that the Channel A 100 kHz low pass filter operates properly:

1. Set 7220A controls as listed under Initial Set-up except for the following changes:

RESOLUTION	1 Hz
CH A/CH B	125 MHz

2. Connect the 7220A and test equipment as illustrated in Figure 4-3.

3. Apply a 1 MHz signal at 10 mV to the Channel A input.

4. Set CH A/CH B to FILT .1 MHz. Observe that the display reads 0.000000 MHz with the input signal voltage level the same as in Step 3.

5. Gradually increase the input signal level until the 7220A again correctly displays 1.000000 MHz (± time base error ±1 count). Verify that the input signal voltage level is 33 mV to 61 mV.

4-28. Attenuation Check

4-29. Use the following procedure to verify proper operation of the 7220A variable and step attenuators:

1. Connect the 7220A and test equipment as illustrated in Figure 4-3.

2. Set the 7220A controls as listed under the Initial Set-up except for CH A/CH B which should be set to 125 MHz. Be sure the attenuators are set as follows:

VAR. ATTENUATION	Fully CCW
STEP ATTENUATION	X1

3. Apply a 1 MHz signal to the Channel A input at 10 mV. Verify that the display is 1 MHz.

4. Change the STEP ATTENUATION to X10. Verify that the display goes to 0.00000 MHz.

5. Change the input signal level to 100 mV. Verify that the display is 1 MHz.

6. Change the VARIABLE ATTENUATION to fully CW. Verify that the display goes to 0.00000 MHz.

7. Change the input signal level to 1V. Verify that the display is 1 MHz.

4-30. Channel B Operation and BURST Check

4-31. Use the following procedure to verify that the Channel B non-BURST and BURST modes operate properly:

NOTE

All signal levels in this section are actual levels. Attenuator settings may be different depending on the calibration of the High Frequency Signal Generator output level.

1. Connect the 7220A and test equipment as illustrated in Figure 4-4. Set 7220A controls as listed under Initial Set-up except for the following changes:

Rear panel REF	INT
Front panel CH A/CH B	1300 MHz

2. Set the High Frequency Signal Generator to 600 MHz with 0 dBm output, and set the attenuator to 25 dB. Verify that the 7220A displays 600 MHz.

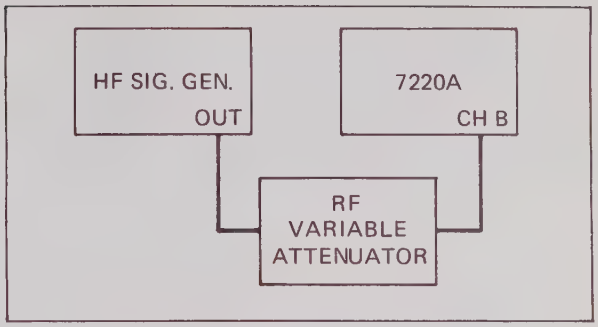


Figure 4-4. Channel B Check

3. Set the attenuator to 31 dB. Verify that the GATE LED turns off and that the display is 0.00000 MHz.

4. Set the CH A/CH B switch to 1300 BURST. Set the High Frequency Signal Generator to 800 MHz with 0 dBm output, and set the attenuator to 32 dB.

5. Press and then release the 7220A front panel RESET switch. Verify a display of 0.00000 MHz and that the GATE LED is not flashing.

6. Set the attenuator to 22 dB. Verify that the 7220A gates once and only once, resulting in a display of 800 MHz.

7. Remove the attenuator and connect the High Frequency Signal Generator directly to the Channel B input. Set the CH A/CH B switch to 1300 MHz.

8. Verify that correct readings are obtained at the input signal frequencies and voltage levels listed in Table 4-6.

Table 4-6. Channel B Input Signals

INPUT SIGNAL	INPUT VOLTAGE
50 MHz	5 mV
600 MHz	5 mV
1000 MHz	10 mV
1300 MHz	40 mV

4-32. External Clock Input Check

4-33. Use the following procedure to verify proper operation of the 7220A rear panel External Clock input.

1. Set the 7220A controls as listed under the Initial Set-up except for the rear panel REF switch, which should be set to EXT.

2. Press and release the front panel RESET and verify the counter reads 0.00000 MHz.

3. Connect the Low Frequency Signal Generator to the 7220A rear panel 10 MHz REF IN input as indicated in Figure 4-5 (the 50 ohm terminator must be connected as shown).

4. Apply a 10 MHz 300 mV signal from the Low Frequency Signal Generator, and verify that the 7220A is gating and the display is 10 MHz.

5. Set the 7220A rear panel REF switch to INT and verify the 7220A is gating and the display is 10 MHz.

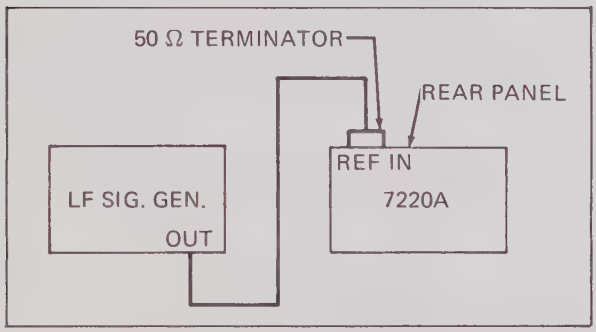


Figure 4-5. External Clock Input Check

4-34. Crosstalk Check

4-35. Use the following procedure to verify that there is no signal crosstalk under normal operating conditions.

1. Connect the 7220A and test equipment as illustrated in Figure 4-6.

2. Set the 7220A controls as listed under the Initial Set-up except for CH A/CH B which should be set to 125 MHz.

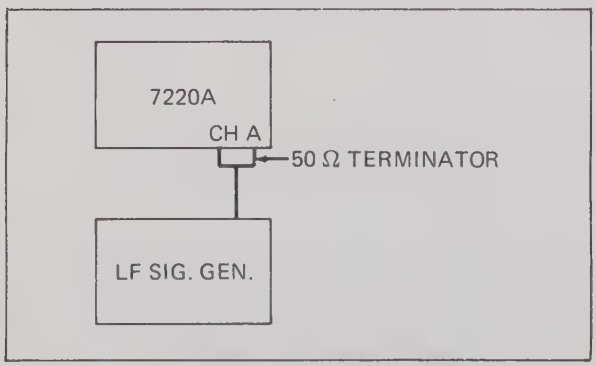


Figure 4-6. Crosstalk Check

3. Apply a 5 MHz 100 mV rms input signal to Channel A. Observe a display of 5 MHz.

4. Set the CH A/CH B to CHK. Observe the display for at least 30 seconds and verify that there is never a reading other than 10.00000 MHz (± time base error ±1 count).

4-36. CALIBRATION ADJUSTMENTS

4-37. These procedures should be performed whenever the instrument has been repaired or fails to pass the Performance Checks. Refer to Table 4-1 when test equipment is required. Unless otherwise specified, refer to the disassembly instructions in the General Maintenance section and remove the top half of the instrument case.

4-38. Power Supply Adjustment

4-39. Use the following procedure to adjust the regulated +5V power supply, to check the regulated +5V, +12V, and -12V power supplies, and to adjust and check the Channel B 6.8V tracking regulator. This procedure should be followed after replacement or repair of the power supply. Line voltage selection of 100V, 120V, 220V, or 240V is provided by switches S4 and S5. S4 and S5 are located on the right rear of the Main PCB, and their position is indicated by a red or white dot. Line voltage selection and the corresponding switch configuration is illustrated in Figure 4-7.

NOTE

See Figure 4-8 for location of test points and trimpots referred to in this procedure.

1. At the ac input receptacle of the 7220A, use the DMM to measure the resistance between the ground pin (center pin) and the chassis. The resistance should be less than 0.1 ohm.

2. Use the DMM to measure the resistance between the two 7220A line voltage pins and the chassis. The resistance should be infinite.

3. Set the variable transformer to 0V and connect to line power. Connect the 7220A line power cord to the variable transformer.

4. Set the 7220A controls as follows:

Rear panel REF	INT
Front panel ON/STBY	ON
BAT/LINE	LINE

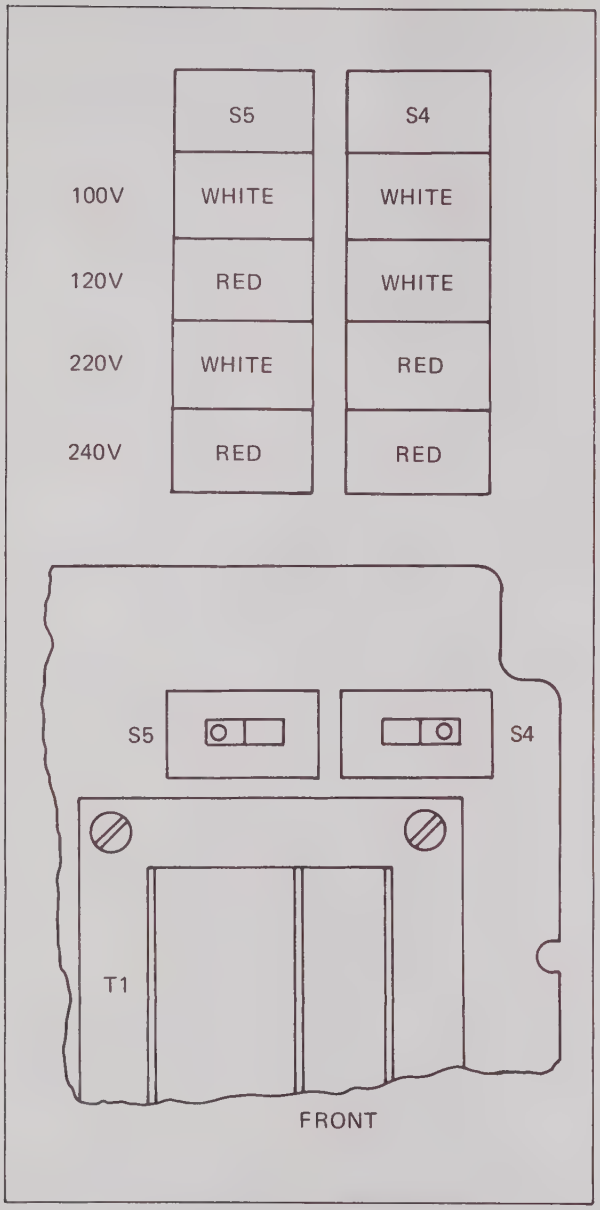


Figure 4-7. Line Voltage Selection

5. Refer to the voltage selection guide in Figure 4-7 and position S4 and S5 to select the line voltage at which the 7220A is to be operated.

6. Slowly raise the variable transformer voltage to the line voltage selected.

7. Connect the DMM positive lead to TP3, and the negative lead to E1 (or any other common ground).

8. While observing the DMM display, adjust R69 to obtain 5.00 ±.01V dc. This adjusts the +5V regulated power supply.

9. Using the DMM and an ac coupled oscilloscope, check the power supply outputs for the tolerance ranges and maximum ripple voltages as given in Table 4-7. In each case the DMM positive lead and the oscilloscope probe should be connected to the test points listed, and the negative lead connected to E1 (or any other common ground).

10. Lower the variable transformer voltage to the selected line voltage minus 10% (for example, if the line voltage selected in Step 5 was 120V, now lower the variable transformer voltage to 108V).

11. Repeat Step 9.

12. Raise the variable transformer voltage to the line voltage selected in Step 5 plus 10%.

13. Repeat Step 9.

NOTE

Steps 5 through 13 may be performed to adjust the +5V regulated power supply and to check the power supplies for any line voltage selected. Before changing the positions of S4 and S5, be sure to reduce the variable transformer voltage to 0V.

14. Be sure S4 and S5 are in the proper position, and return the variable transformer voltage to the line voltage selected.

15. Set the 7220A CH A/CH B control to 1300 MHz. Connect the DMM positive lead to TP8 and the negative lead to TP9.

16. While observing the DMM display, adjust R14 to obtain 6.80 ±.05V dc. This adjusts the Channel B 6.8V tracking regulator.

17. Set the 7220A CH A/CH B control to 125 MHz. Use the DMM to verify that the voltage between TP8 and TP9 is now 0.2 + 0.1V dc.

Table 4-7. Power Supply Levels

TESTPOINT	SUPPLY	TOLERANCE	MAXIMUM RIPPLE
TP3	+5V	±0.01V	50 mV p-p
TP1	+12V	±0.5V	50 mV p-p
TP2	-12V	±0.5V	50 mV p-p

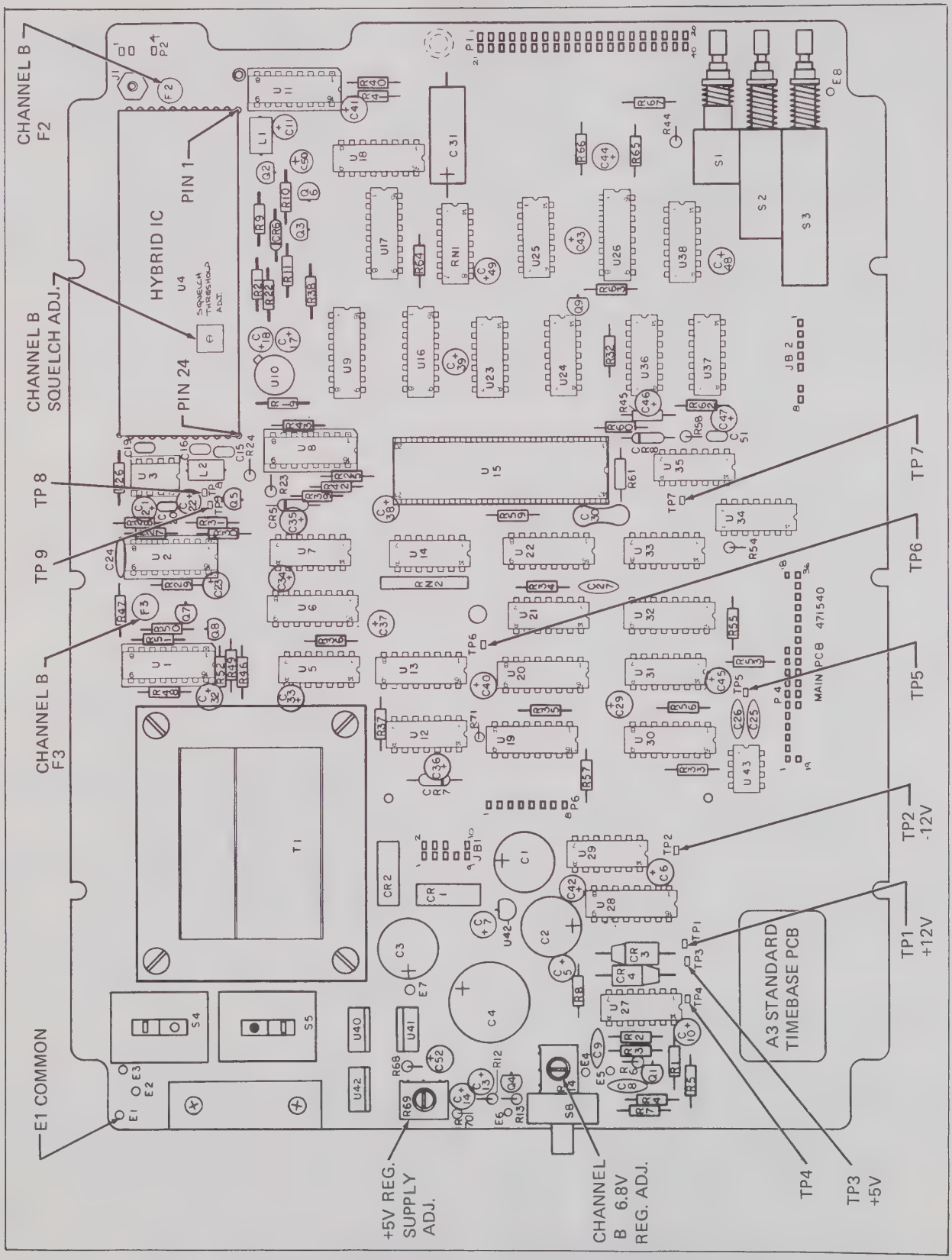


Figure 4-8. Main PCB Testpoint and Adjustment Location

4-40. Channel A Trigger Level Adjustment

4-41. Use the following procedure to adjust the Channel A Trigger Level Adjustment:

1. Using appropriate BNC adapters, connect the Low Frequency Signal Generator and the rf voltmeter with a 50 ohm terminator to the Channel A input of the 7220A. This is illustrated in Figure 4-9.

2. Set the 7220A controls as follows:

Rear panel	
REF	INT
Front panel	
ON/STBY	ON
BAT/LINE	LINE
RESOLUTION	10 Hz
CH A/CH B	125 MHz
VAR. ATTENUATOR	Fully CCW
STEP ATTENUATOR	X1

3. Apply 1 MHz at 10 mV rms to Channel A. Adjust R10 Trigger Adjust trimpot (located on the top of A2, the Front Panel PCB; see Figure 4-10) if necessary to obtain a reading of 1.00000 MHz (± time base error ±1 count). Reduce input voltage level and continue to adjust R10 to obtain the correct display, but do not reduce the voltage level below 4.7 mV rms.

4. If R10 cannot be adjusted to obtain the correct reading at the 4.7 mV rms input level, adjust it midway between fully CW and fully CCW. Turn the R11 Hysteresis Adjust trimpot (located on the right rear of A2, the Front Panel PCB; see Figure 4-10) fully CW. Then slowly turn R11 CCW until the correct reading is displayed.

NOTE

Do not turn R11 CCW beyond the point where the correct reading is first displayed.

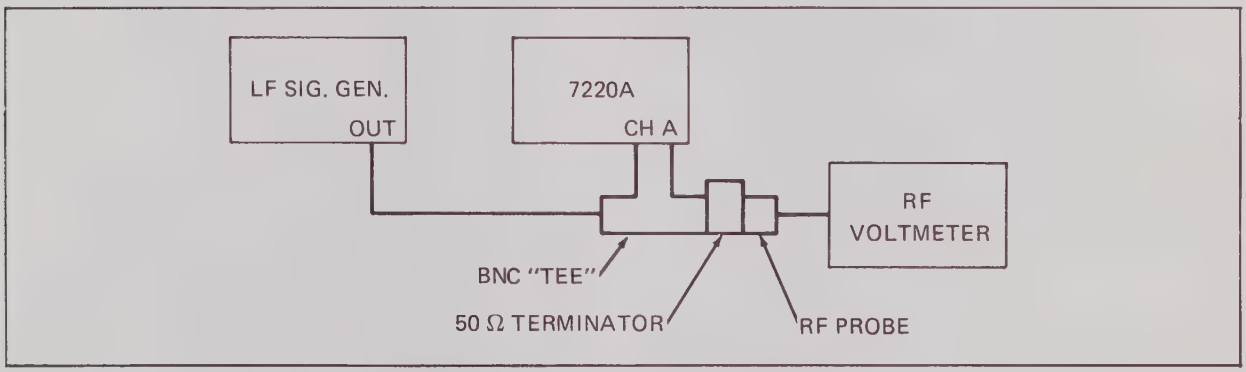


Figure 4-9. Channel A Trigger Level Adjustment

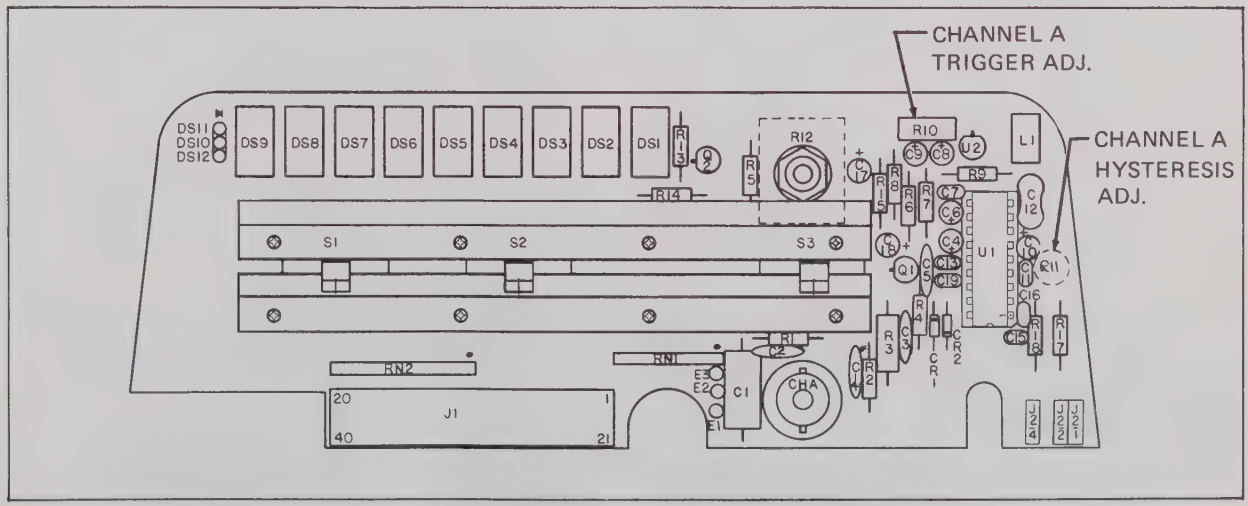


Figure 4-10. Front Panel PCB Adjustment Location

5. Recheck R10 as in Step 3.

6. Recheck R11 as in Step 4.

7. Decrease the input voltage level to 4.25 mV rms. Verify that the 7220A displays unstable, fluctuating readings less than 1.00000 MHz. If the display still indicates 1.00000 MHz (± time base error ±1 count), repeat Steps 4-6.

4-42. Channel B Squelch Adjustment

4-43. Use the following procedure for the Channel B Squelch Adjustment:

1. Connect the 7220A and test equipment as indicated in Figure 4-11.

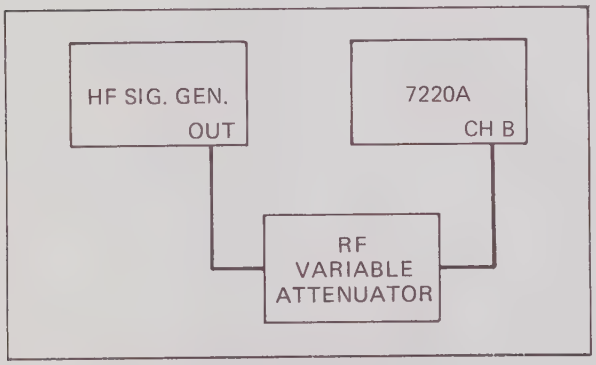


Figure 4-11. Channel B Squelch Adjustment

2. Set the 7220A controls and indicators as follows:

Rear panel	
REF	INT
Front panel	
ON/STBY	ON
BAT/LINE	LINE
RESOLUTION	10 Hz
CH A/CH B	1300 MHz
VAR. ATTENUATOR	Fully CCW
STEP ATTENUATOR	X1

3. Set the High Frequency Signal Generator to 600 MHz at 0 dBm, and the attenuator to 29 dB.

4. Turn the Squelch Adjust trimpot (located on the Channel B hybrid IC, U4; see Figure 4-8) fully CCW. Then adjust the trimpot CW until the 7220A displays 600 MHz.

5. Change the attenuator to 31 dB. Verify that the GATE LED turns off and that the display is 0.00000 MHz. If the 7220A still displays 600 MHz, repeat Steps 4 and 5 until the 7220A displays 600 MHz at 29 dB attenuation, and 0.00000 MHz at 31 dB attenuation.

4-44. Standard Time Base Calibration

4-45. Calibration should be made whenever the time base is repaired or replaced, or when it is determined that the instrument accuracy is not within the Specifications given in Section 1. The following procedure is to be used for calibration of a standard time base. Calibration procedures for any of the optional time bases (Options -111, -131, or -132) are provided in Section 6. The calibration should be performed in an environment having an ambient temperature between 20° and 30° C (68° and 86° F).

NOTE

The 7220A must be operating for at least thirty minutes with top and bottom covers on before this procedure is followed.

1. Set the 7220A controls as follows:

Rear panel	
REF	INT
Front panel	
ON/STBY	ON
BAT/LINE	LINE
RESOLUTION	1 Hz
CH A/CH B	125 MHz
VAR. ATTENUATION	Fully CCW
STEP ATTENUATION	X1

2. Connect the 7220A and test equipment as illustrated in Figure 4-12.

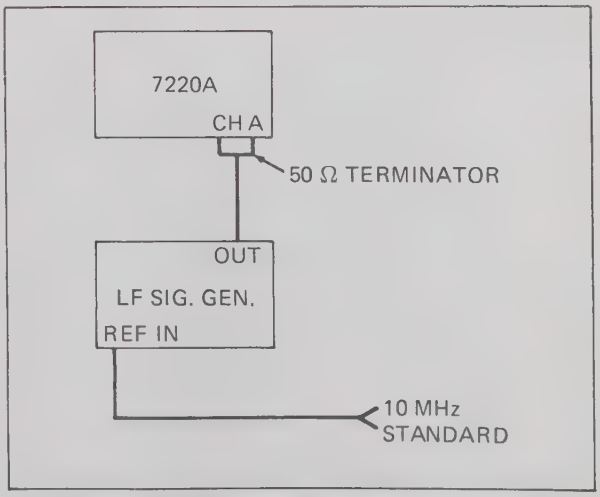


Figure 4-12. Standard Time Base Calibration

NOTE

The Low Frequency Signal Generator must be synchronized to a Standard Frequency Source for this procedure.

3. Set the Low Frequency Signal Generator to 10 MHz at 100 mV rms and connect it to the Channel A input with a 50 ohm terminator.

4. Using a non-ferrous adjustment tool, adjust the oscillator trimcap to obtain a display of 10.000000 MHz ± 57 Hz. 57 Hz is the maximum allowable deviation for this time base at this input frequency and resolution setting. The maximum allowable deviation can be found by multiplying the input frequency by the total accuracy, and adding the 1 count error (see Table 4-3). The oscillator trimcap is accessible through a hole at the left rear corner of the bottom of the 7220A (see Figure 4-13), so the 7220A will have to be turned on its side or top to perform this adjustment. If the tilt bail is mounted in the rear, it will have to be removed.

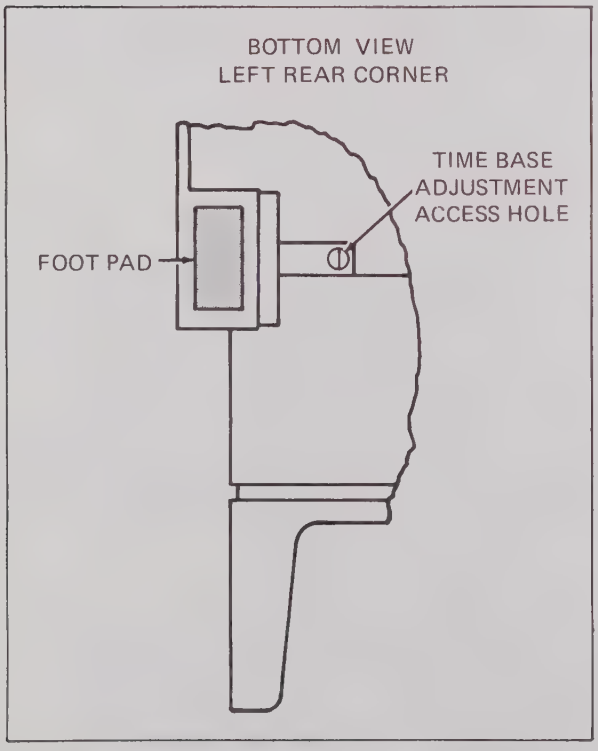


Figure 4-13. Time Base Adjustment Location

5. If adjustment does not yield the desired display, disconnect the 7220A line power cord, remove the top cover, and look at the top of the time base PCB (left rear corner of the Main PCB). Some of the Standard Time Bases are equipped with another trimcap on the top of the PCB for coarse adjustments. If your instrument has such a trimcap, refer to the Coarse Time Base Adjustment section which follows this section.

6. If the time base cannot be adjusted within the Specifications given in Section 1 and coarse adjustment is not available, refer to Troubleshooting.

7. After 24 hours, recheck any adjustment performed to verify stability.

4-46. Coarse Time Base Adjustment

4-47. Some of the Standard Time Bases have a coarse adjustment trimcap on the top of the PCB in addition to the fine adjustment trimcap which is accessible through a hole in the bottom of the instrument case (see Figure 4-13).

NOTE

Do not perform the Coarse Time Base Adjustment unless the Standard Time Base Calibration fails to bring the instrument within the specifications.

If it is determined that coarse adjustment is necessary, use the following procedure:

1. Set the fine time base adjustment to midrange.

2. Remove the 7220A top cover.

3. Follow steps 1, 2 and 3 of the Standard Time Base Calibration.

4. Using a non-ferrous adjustment tool, adjust the coarse adjustment trimcap to obtain a display as close as possible to 10.000000 MHz.

5. Install the 7220A top cover. Now perform the Standard Time Base Calibration.

4-48. TROUBLESHOOTING

4-49. Introduction

4-50. The material in the remainder of this section is presented as a troubleshooting aid for technicians. If the instrument fails to perform as expected, select the CHK function. If the instrument display is incorrect, the fault is in the instrument; if the display is correct, the fault may not lie in the instrument. Check the control settings for the 7220A. Also check the control settings, function, and interconnections of all associated equipment.

4-51. Sections 2 and 3 of this manual should be read and thoroughly understood before attempting to troubleshoot. As an aid to the troubleshooter, three additional subsections follow: Visual Inspection, Troubleshooting Guide, and Troubleshooting Techniques.

4-52. Whenever working with the instrument, follow procedures outlined on the yellow Static Awareness sheet located in this manual to prevent static discharge damage to CMOS and PMOS devices. Exercise special care when soldering to avoid damage to the instrument.

4-53. The instrument uses three basic types of logic: ECL, TTL, and CMOS. The circuits handling high frequency signals employ Emitter-Coupled Logic (ECL). Circuitry using CMOS ICs operate at CMOS logic levels. The remainder of the instrument employs Transistor-Transistor Logic (TTL). Table 4-8 lists typical high and low logic levels for each logic type.

Table 4-8. Typical Logic Levels

LOGIC TYPE	LOGIC 1	LOGIC 0
TTL	>2.4V	<0.6V
ECL	>4.1V	<3.2V
CMOS	>3.5V (>70% of supply)	<1.5V (<30% of supply)

4-54. Visual Inspection

4-55. Visual inspection can sometimes quickly locate instrument faults, saving the technician time. Use the Disassembly procedure presented earlier in this section to remove the top case cover. Carefully inspect the instrument, inside and out. Check for loose or broken wires and component leads, improperly seated plug-in assemblies, physically damaged components, discoloration due to arcing, or other obvious faults. Shorted capacitors or resistors in short paths are often discolored or burnt. Abusively high overloads may physically destroy carbon composition resistors, glass diodes, ceramic capacitors, thermistors, and other components. These symptoms or anything that looks suspect should be carefully checked before proceeding with involved troubleshooting.

4-56. Troubleshooting Guide

4-57. The Troubleshooting Guide, Table 4-9, provides some basic guidelines for locating the cause of improper operation. There are three basic cases of improper operation:

1. The instrument will not turn on. Check the main power supply per Table 4-9.

2. The instrument turns on, but the problems seem to be spread throughout the instrument or are erratic. This situation may be due to any of a number of power supply related problems. Check the power supplies per Table 4-9.

3. The instrument has a problem in one or more functions or ranges. Follow the guidelines in Table 4-9 for the appropriate circuit.

NOTE

See Figure 4-8 for the location of testpoints and identification of components. Use a 10X probe on the oscilloscope.

WARNING

TO AVOID SHOCK HAZARD, DO NOT TOUCH POWER SUPPLY COMPONENTS. LINE POWER VOLTAGE IS PRESENT FROM THE POWER CORD THROUGHOUT THE PRIMARY CIRCUIT OR THE MAIN POWER TRANSFORMER.

4-58. Troubleshooting Techniques

4-59. The following are techniques useful in isolating a fault in the instrument.

4-60. CURRENT TRACING

4-61. Current Tracer probes, such as the HP 547A, are usually the best way to locate shorts in the instrument. If the short is so bad that the power supply is loaded down, the Performance Checks may not provide any help in isolating the faulty circuit. Starting at the output of the loaded power supply, logically move the Current Tracer through the instrument until the short is found. The Current Tracer will glow brightest at the terminal of the shorted components. Shorted logic elements can be more difficult to locate because currents involved can be small.

4-62. HEATING AND COOLING

4-63. Alternately warming (with a heat gun) and cooling (with freon spray) of possible faulty circuits can provide a fast and effective troubleshooting technique for finding components that work intermittently.

4-64. MEASURING TEMPERATURE

4-65. Shorted components overheat. Resulting temperature differences can be monitored with the Fluke 80T-150 and any of its associated digital multimeters, or with the 8024 DMM with an accessory thermocouple attached.

Table 4-9. Troubleshooting Guide

PROBLEM	INSTRUCTIONS OR COMMENTS
Power Supply	Check ac power receptacle pins, power supplies, line voltage selector switches, Fuse F1. Check TP1, TP2, and TP3 for values listed in Table 4-7. Hint: If supplies are OK with front panel ON/STBY switch in STBY, but fail in ON, components outside the supplies may be shorted. Hint: Make certain that regulator ICs (U40, U41, and U42) are properly tightened to the heatsink, and that the heatsink is tightened to the circuit board.
Time Base and Clocking Signals	Be sure the rear panel REF switch is set to INT. Check: — You should see: TP4 — 10 MHz, TTL (clock) U19-13 — 1 MHz, TTL U19-3 — 100 kHz, TTL U28-7 — Approx. 63 kHz, CMOS (used only in Channel B) U28-3 — Approx. 61 Hz, CMOS (Scan rate clock that advances Sequencer U32) U15-40 — Approx. 1.2 kHz (U15 display oscillator)
Self Check, Control Logic and Counters	Set the CH A/CH B switch to CHK and set RESOLUTION to 10 Hz. Be sure the rear panel REF switch is set to INT. Display should be 10.00000 MHz. Refer to the Timing Diagram in Figure 3-7. Check: — You should see:
Sequencer	U32-4 (Q2 state) — Positive pulses, slightly wider than gate time of 0.1 sec. U32-3 (Q0 state) — Positive pulses U32-10 (Q4 state) — Positive pulses U32-1 (Q5 state) — Positive pulses U32-11 (Q9 state) — Positive pulses
Main Gate FF	U13-5 — Positive pulse, 0.1 sec. wide
Gate Synchronizer	U7-8 — Negative pulse, 0.1 sec. wide
Input Counters	U1-4 — 10 MHz, ECL U5-3 — 5 MHz, TTL when gate is on U6-9 — 1 MHz, TTL when gate is on U14-8 — 0.1 MHz, TTL when gate is on
Channel B	Set the front panel CH A/CH B switch to 1300 MHz. Check the Channel B power supplies: Input Fuse F2 TP8 — +5V TP9 — -1.8V U4-1 — +12V U4-23 — -12V

Table 4-9. Troubleshooting Guide (cont)

PROBLEM	INSTRUCTIONS OR COMMENTS
Channel B (cont)	Apply a signal to Channel B input within specifications (100-1300 MHz, 40 mV-5V rms)
	Q6 collector — TTL low U3-4 — Input/4, ECL U3-2 — Input/16, ECL U1-4 — Input/16, ECL
Channel B BURST	Set the front panel CH A/CH B switch to 1300 BURST. Apply signal to Channel B as above, only in bursts at least as long as 40 ms + gate time (see Table 3-1 for gate times).
	U21-6 — Low, CMOS U21-3 — Positive pulses, CMOS, same width as input bursts U21-2 — Pulses U1-4 — Input/16, ECL
Channel A (front panel)	Hint: If excessive input voltages have been applied to the Channel A input, it is likely that Q1 is damaged, or that CR1 or CR2 are leaky.
	Set front panel CH A/CH B switch to 125 MHz. Apply signal to Channel A input between 10 Hz and 125 MHz, and at a level equal to the sensitivity specification at the frequency used. Set attenuation controls to X1 and fully CCW. If necessary, refer to the Disassembly instructions and remove the front panel first.
	Q1-Drain — Approx. +11.5V Q1-Gate — Same as input U1-11 — Same as input U1-12 — -5V U1-2 and U1-3 — Approx. square wave, same frequency as input, ECL U1-18 — Approx. square wave, same frequency as input, TTL
Display	Hint: To test the LEDs, press and hold front panel RESET to turn on all segments. If only one segment is dark, suspect the LED. If an entire digit is dark, or the same segment on all digits is dark, suspect the digit drive or segment drive electronics respectively.
	To test decimal points, remove any inputs to the 7220A. Set POWER to ON. Set the CH A/CH B switch to RES MULT and check for a single decimal point at each RESOLUTION setting. Set the CH A/CH B switch to any other setting and check for a single decimal point at each RESOLUTION setting.
	Also check:
	U15-40 — Approx. 1.2 kHz pulses (display clock) U15-2 — Positive pulses, 22% duty factor (digit strobes 8 and 9) U15 pins 3 through 9 — Positive pulses, 11% duty factor (digit strobes 7 through 1) U18-4 — Positive pulse, 11% duty factor (digit strobe 9)
	Set CH A/CH B switch to CHK and RESOLUTION to 100 Hz with no signal inputs.
	U35-2 — Positive pulse, 66% duty factor (leading zeros blanking)

Section 5
List of Replaceable Parts

TABLE OF CONTENTS

ASSEMBLY NAME	DRAWING NO.	TABLE NO.	TABLE PAGE	FIGURE NO.	FIGURE PAGE
Final Assembly	7220A-T&B, 5001	5-1	5-3	5-1	5-5
A1 Main PCB Assembly	7220A-4001T	5-2	5-8	5-2	5-13
A2 Front Panel PCB Assembly	7220A-4002T	5-3	5-14	5-3	5-16
A3 Timebase PCB Assembly	1952B-4010T	5-4	5-17	5-4	5-17

5-1. INTRODUCTION

5-2. This section contains an illustrated parts list for the instrument. A similar parts listing for each of the Options will be found in Section 6. Components are listed alphanumerically by assembly. Both electrical and mechanical components are listed first by reference designation and second by item number. Each listed part is shown in an accompanying illustration.

5-3. Parts lists included the following information:

1. Reference Designation or Item Number.

2. Description of each part.

3. FLUKE Stock Number.

4. Federal Supply Code for Manufacturers. (See Section 7 for Code-to-Name list.)

5. Manufacturer's Part Number or Type.

6. Total Quantity per assembly or component.

7. Recommended Quantity: This entry indicates the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of each assembly in the instrument be stocked. In the case of optional subassemblies, plug-ins, etc., that are not always part of the instrument, or are deviations from the basic instrument model, the REC QTY column lists the recommended quantity of the item in that particular assembly.

8. The Use Code: This entry indicates a note number. The corresponding note will be at the end of that table.

5-4. HOW TO OBTAIN PARTS

5-5. Components may be ordered directly from the manufacturer by using the manufacturer's part number, or from the John Fluke Mfg. Co., Inc. factory or authorized representative by using the FLUKE STOCK NUMBER. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions if necessary.

5-6. To ensure prompt and efficient handling of your order, include the following information.

1. Quantity.

2. FLUKE Stock number.

3. Description.

4. Reference Designation or Item Number.

5. Printed Circuit board Part Number.

6. Instrument Model and Serial Number.

CAUTION

Indicated devices are subject to damage by static discharge.

Figure 5-1. Final Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	⊘FINAL ASSEMBLY, 7220A FIGURE 5-1 (7220A-T&B, 5001)						
A1	MAIN PCB ASSY, TESTED	471540	89536	471540	1		
A2	FRONT PANEL PCB ASSY	471516	89536	471516	1		
A3	TIMEBASE PCB ASSY	406926	89536	406926	1		
F1	FUSE, SLO-BLOW, 1/4 AMP	166306	71400	MDL1-4	1		5
H1	LOCKWASHER, SPLIT #4	110395	89536	110403	2		
H2	NUT, HEX	110916	73734	17-200-NP	1		
H3	NUT, HEX, 4-40	110635	89536	110635	2		
H4	NUT, SELF LOCK, 6-32	152819	78199	511-061800-00	4		
H5	SCREW, FHP, CNTR. SUNK, 6-32 X 5/8	114876	89536	114876	6		
H6	SCREW, PHP, 4-40 X 1/2	152132	73734	19026	4		
H7	SCREW, PHP, 6-20 X 3/8	288266	89536	288266	1		
H8	SCREW, PHP, 6-32 X 1/2	177030	89536	177030	2		
H9	SCREW, THD. FORM, 6-32 X 3/8, BLK	485227	89536	485227	6		
H10	WASHER, INT/LK, #4	110403	89536	110403	2		
H11	WASHER, LOCK, EXT. TOOTH	175943	89536	175943	1		
H12	WASHER, SHOULDER	485417	89536	485417	2		
MP1	BOTTOM COVER, ASSY	489302	89536	489302	1		
MP2	BUSHING, INSULATION	488429	89536	488429	2		
MP3	BUTTON, BLUE	486472	89536	486472	1		
MP4	BUTTON, GREEN	486498	89536	486498	1		
MP5	BUTTON, LIGHT PUTTY GRAY	486480	89536	486480	1		
MP6	CONNECTOR, BNC	152033	95712	30355-1	2		
MP7	COVER, CONNECTOR	488395	89536	488395	1		
MP8	FRONT PANEL	478396	89536	478396	1		
MP9	GROMMET	104273	72653	7582	1		
MP10	HEAT SINK	473868	89536	473868	1		
MP11	INSULATOR, RUBBER	534453	89536	534453	2		
MP12	INSULATOR, TRANSFORMER	507517	89536	507517	1		
MP13	KNOB ASSY	490755	89536	490755	1		
MP14	LABEL, WARNING	386250	89536	386250	1		
MP15	LATCH	467548	89536	467548	2		
MP16	LUG, SOLDER	441972	79963	761	1		
MP17	REAR PANEL	475939	89536	475939	1		
MP18	SERIAL NAMEPLATE	472795	89536	472795	1		
MP19	SPEC DECAL	483032	89536	483032	1		
MP20	TOP COVER ASSY	489310	89536	489310	1		
T1	TRANSFORMER	486514	89536	486514	1		
TM1	INSTRUCTION MANUAL (7220A) (NOT SHOWN)	487488	89536	487488	1		
U1	IC, ECL, EDGE-TRIGGERED, JK FLIP FLOP	402743	07263	F95029DC	1		1
U2	IC, ECL, TRIPLE LINE RECEIVER 16-PIN DIP	369702	18324	N10116B	2		1
U3	IC, ECL 1600 SER DIV-BY-4 GHZ PRESCALER	472787	04713	MC1697P	1		1
U4	IC, HYBRID, CHANNEL B PRESCALER	490664	89536	490664	1		1
U8	IC, ECL, QUAD, 2-INPUT NOR, 16-PIN DIP	380881	04713	MC10102P	1		1
U11	IC, ECL, TRIPLE LINE RECEIVER 16-PIN DIP	369702	18324	N10116B	REF		
U15⊘	IC, 6-DEC MOS UP COUNTER W/8 DEC LATCH	473215	89536	473215	1		1
U39	IC, LIN, NEG VOLT, REG SERIES 2-24 VOLTS	394551	04713	MC905CT	1		1
U40	IC, VOLTAGE REGULATOR, FIXED VOLTAGES	413195	04713	MC7812CT	1		1

NOTE: ⊘ Indicates the item can be damaged by static discharge.

Table 5-1. Final Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
U41	IC, LIN, ADJUST VOLT REG 1.2-37V, 1.5A	460410	89536	460410	1	1	
W1	LINE CORD (NOT SHOWN)	343723	12040	LM317T	1		
W2	AC CABLE ASSY, GREEN	504068	89536	504068	1		
W3	AC CABLE ASSY, WHITE	504050	89536	504050	1		
W4	AC CABLE ASSY, BLACK	504076	89536	504076	1		
W5	CABLE ASSY	539833	89536	539833	1		
XF1	FUSEHOLDER, W/NUT	460329	89536	460329	1		
	FUSEHOLDER, CAP	460238	89536	460238	1		
	RECOMMENDED SPARE PARTS LIST/KIT, 7220A	583625	89536	583625	AR		

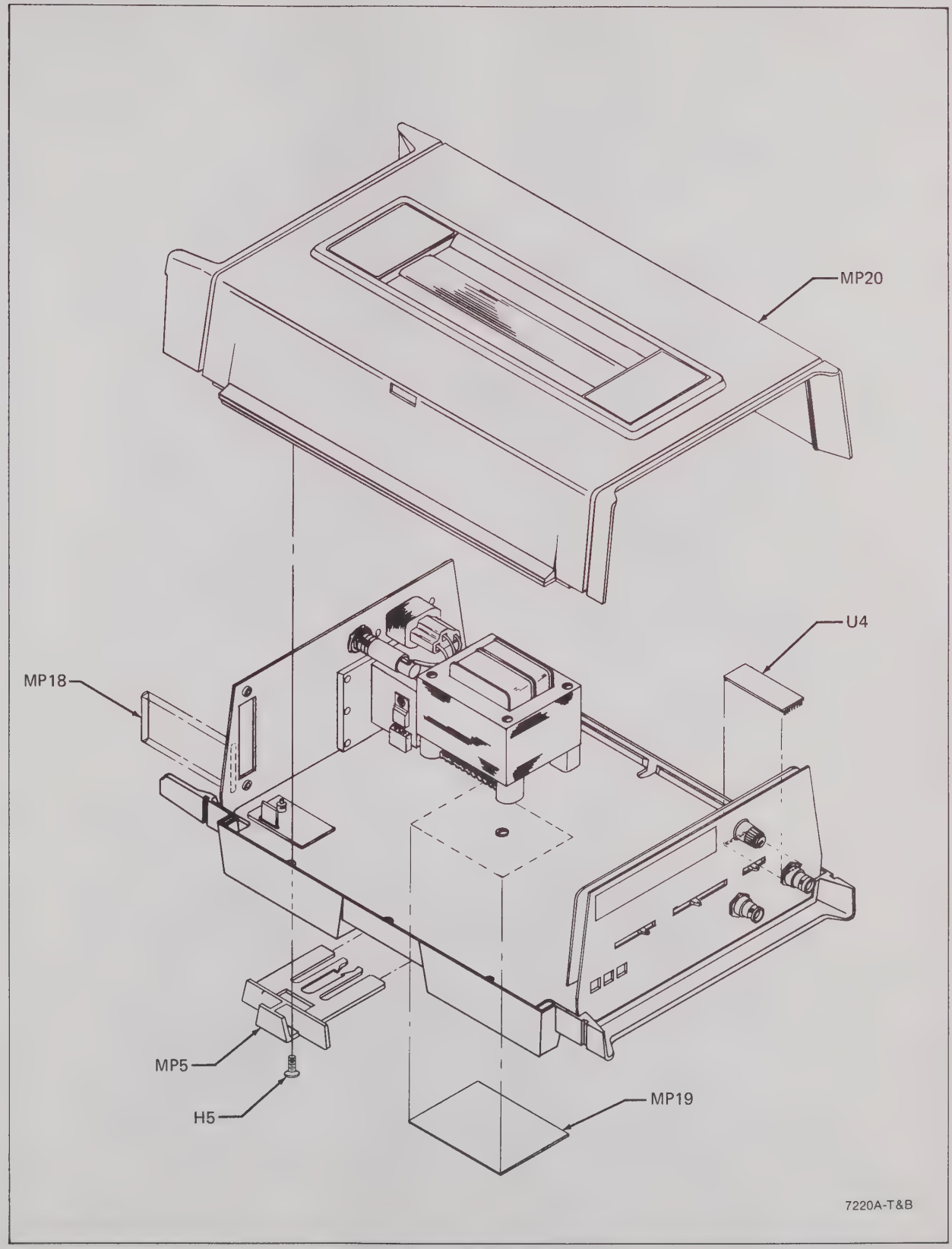


Figure 5-1. Final Assembly

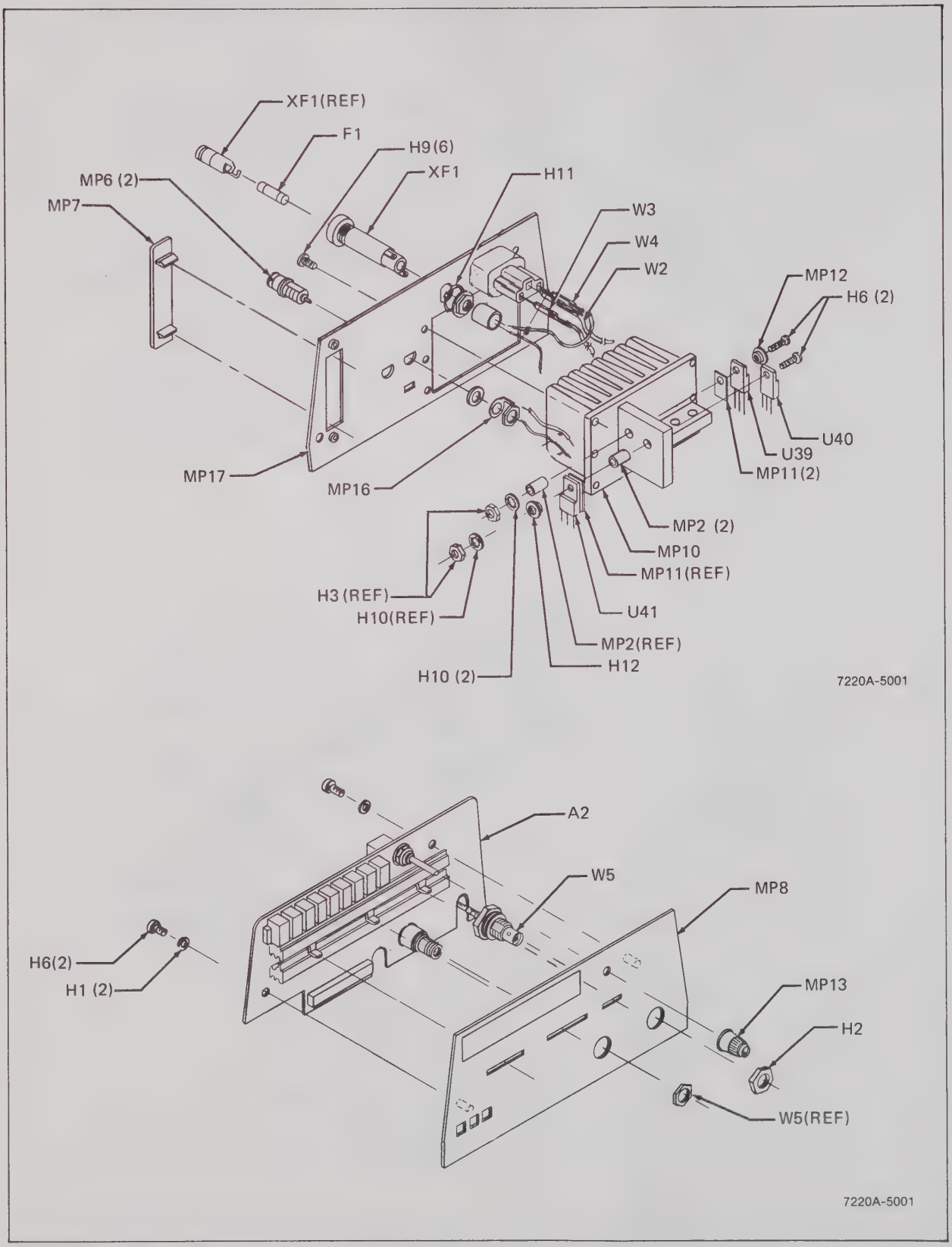


Figure 5-1. Final Assembly (cont)

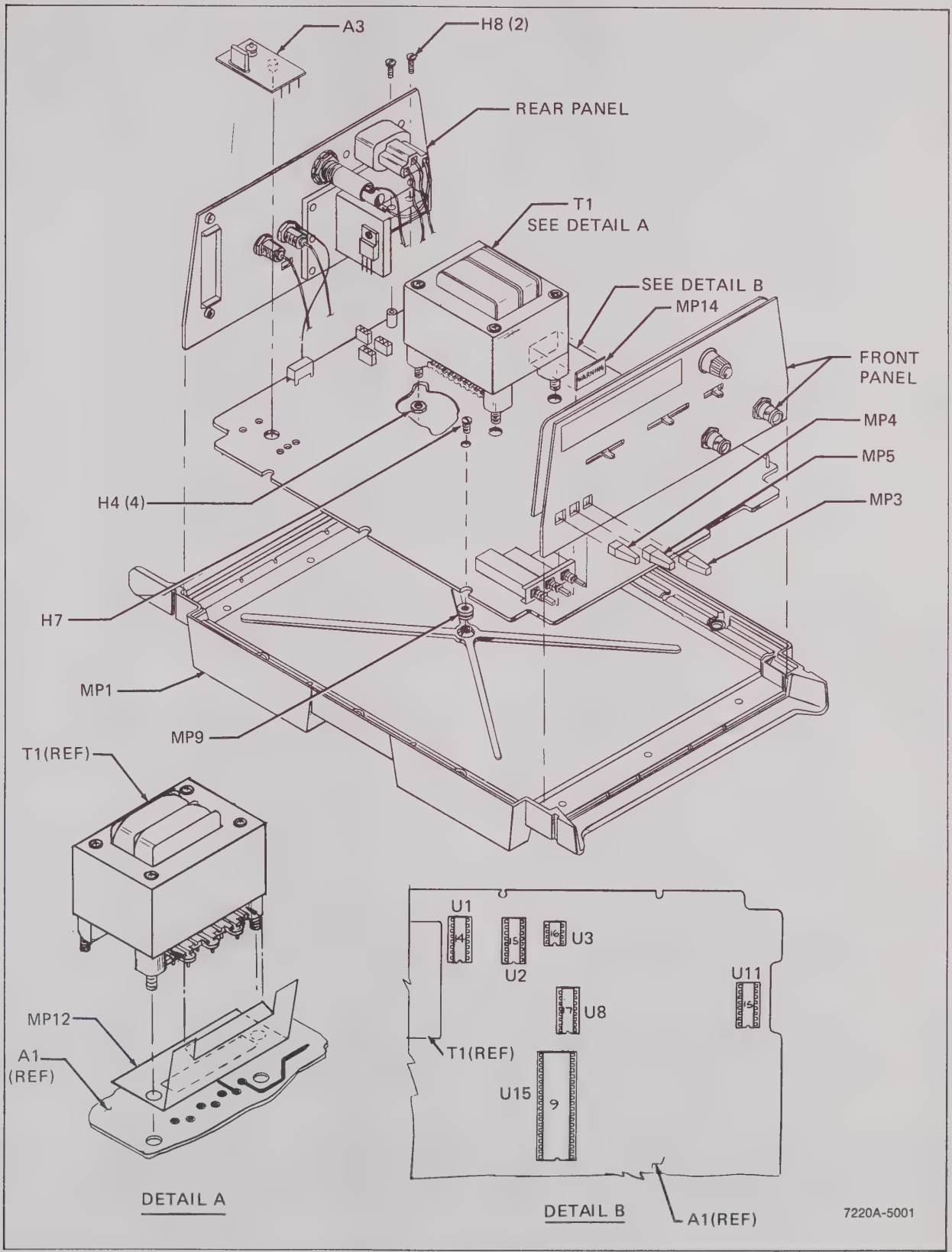


Figure 5-1. Final Assembly (cont.)

Table 5-2. A1 Main PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	⊗MAIN PCB ASSEMBLY FIGURE 5-2 (7220A-4001T)	471540	89536	471540	REF		
C1	CAP, ELECT, 470 UF -10/+25%, 35V	478792	89536	478792	3		
C2	CAP, ELECT, 470 UF -10/+25%, 35V	478792	89536	478792	REF		
C3	CAP, ELECT, 470 UF -10/+25%, 35V	478792	89536	478792	REF		
C4	CAP, ELECT, 4700 UF -10/+100%, 18V	460261	80031	314TS502V015	1		
C5	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	32		
C6	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C7	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C8	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	5		
C9	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C10	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C11	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C13	CAP, TA, 22 UF +/-20%, 15V	423012	56289	196D226X0015KA1	1		
C14	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C15	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	5		
C16	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C17	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C18	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C19	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C20	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C21	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C22	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C23	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C24	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C25	CAP, CER, 0.1 UF +/-20%, 100V	149146	56289	33C4186	1		
C26	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C27	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C29	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C30	CAP, MICA, 5000 PF +/-5%, 500V	181065	72136	DM15502-J	1		
C31	CAP, CER, 330 UF +/-10%, 6V	193011	56289	150D330X9006S2	1		
C32	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C33	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C34	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C35	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C36	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C37	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C38	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C39	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C40	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C41	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C42	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C43	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C44	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C45	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C46	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C47	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C48	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C49	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		

Table 5-2. A1 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
C50	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C51	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	REF		
C52	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
CR1	DIODE, RECTIFIER BRIDGE	296509	21845	F903C-22	2	1	
CR2	DIODE, RECTIFIER BRIDGE	296509	21845	F903C-22	REF		
CR3	DIODE, SI, RECTIFIER, 2 AMP, 50V	347559	14099	3SM05	2	1	
CR4	DIODE, SI, RECTIFIER, 2 AMP, 50V	347559	14099	3SM05	REF		
CR5	DIODE, ZENER 5.6V	277236	07910	1N752A	1	1	
CR6	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	3	1	
CR7	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
CR8	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
F2	FUSE, 1/5 AMP	370577	75915	273.200	2	10	
F3	FUSE, 1/5 AMP	370577	75915	273.200	REF		
J1	SOCKET, CONNECTOR	352450	98291	51-051-0000	1		
JB1-JB2	CONNECTOR, PIN	379438	00779	1-87022-0	102		
L1	CHOKE, 6-TURN	320911	89536	320911	2		
L2	CHOKE, 6-TURN	320911	89536	320911	REF		
MP1	GUIDE PIN (NOT SHOWN)	375840	89536	375840	3		
MP2	SOCKET PINS (USED W/U4)	376418	22526	75060-007	23		
MP3	SPACER, STANDOFF	442913	89536	442913	1		
P1	CONNECTOR, PIN	379438	00779	1-87022-0	REF		
P2	CONNECTOR, PIN	379438	00779	1-87022-0	REF		
P4	CONNECTOR, PIN	379438	00779	1-87022-0	REF		
P6	CONNECTOR, PIN	379438	00779	1-87022-0	REF		
Q1	XSTR, SI PNP	195974	04713	2N3906	1	1	
Q2	XSTR, SI, PNP	352369	12040	2N4403	1	1	
Q3	XSTR, SI, NPN	218396	04713	2N3904	4	1	
Q4	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q5	XSTR, SI, NPN	330803	07263	MPS6560	1	1	
Q6	XSTR, SI, NPN	218396	04713	2N3904	REF		
Q7	XSTR, PNP, HI-SPEED SWITCHING	369629	07263	543576	2	1	
Q8	XSTR, PNP, HI-SPEED SWITCHING	369629	07263	543576	REF		
Q9	XSTR, SI, NPN	218396	04713	2N3904	REF		
R1	RES, DEP. CAR, 1.8K +/-5%, 1/W	441444	80031	CR251-4-5P1K8	1		
R2	RES, DEP. CAR, 180 +/-5%, 1/4W	441436	80031	CR251-4-5P180E	1		
R3	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	5		
R4	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	2		
R5	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	8		
R6	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	REF		
R7	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	3		
R8	RES, DEP. CAR, 27 +/-5%, 1/4W	348763	80031	CR251-4-5P27E	3		
R9	RES, DEP. CAR, 47K +/-5%, 1/4W	348896	80031	CR251-4-5P47K	1		
R10	RES, DEP. CAR, 2.4K +/-5%, 1/4W	441493	80031	CR251-4-5P2K4	1		
R11	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	10		
R12	RES, MTL. FILM, 301 +/-1%, 1/8W	267740	91637	CMF553010F	1		
R13	RES, MTL. FILM, 43.2 +/-1%, 1/8W	296731	91637	CMF5543R2F	1		
R14	RES, VAR, 50 +/-10%, 1/2W	447862	11236	360T500A	1		
R19	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R21	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R22	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		

Table 5-2. A1 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R23	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R24	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R25	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R26	RES, DEP. CAR, 100 +/-5%, 1/4W	348771	80031	CR251-4-5P100E	REF		
R27	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	9		
R28	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R29	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R30	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R31	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R32	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R33	RES, DEP. CAR, 330K +/-5%, 1/4W	376640	80031	CR251-4-5P330K	1		
R34	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	1		
R35	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R36	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R37	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	5		
R38	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R39	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R40	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R41	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R42	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R43	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R44	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	2		
R45	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	REF		
R46	RES, DEP. CAR, 240 +/-5%, 1/4W	376624	80031	CR251-4-5P240E	2		
R47	RES, DEP. CAR, 240 +/-5%, 1/4W	376624	80031	CR251-4-5P240E	REF		
R48	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R49	RES, DEP. CAR, 27 +/-5%, 1/4W	348763	80031	CR251-4-5P27E	REF		
R50	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R51	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
R52	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	REF		
R53	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R54	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R55	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R56	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R57	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R58	RES, DEP. CAR, 6.8K +/-5%, 1/8W	368761	80031	CR251-4-5P6K8	1		
R59	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R60	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R61	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R62	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R63	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R64	RES, DEP. CAR, 1.3 +/-5%, 1/4W	442012	80031	CR251-4-5P1E3	1		
R65	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	3		
R66	RES, DEP. CAR, 27 +/-5%, 1/4W	348763	80031	CR251-4-5P27E	REF		
R67	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	REF		
R68	RES, MTL. FILM, 1K +/-1%, 1/8W	168229	91637	CMF551001F	1		
R69	RES, VAR, 200 +/-10%, 1/2W	275743	89536	275743	1	1	
R70	RES, MTL. FILM, 3.01K +/-1%, 1/8W	312645	91637	CMF553011F	1		
R71	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	REF		
RN1	RESISTOR NETWORK	412866	89536	412866	1		

Table 5-2. A1 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
RN2	RESISTOR NETWORK, 4.7K +/-2%, 1/8W	412916	89536	412916	1		
S1,2,3	PUSHBUTTON ASSY	473991	89536	473991	1		
S4	SWITCH, SLIDE, DPDT	234278	89536	234278	2		
S5	SWITCH, SLIDE, DPDT	234278	89536	234278	REF		
S8	SWITCH, SLIDE	354878	89536	354878	1		
TP1-TP9	CONNECTOR, PIN	379438	00779	1-87022-0	REF		
U1	SEE FINAL ASSEMBLY TABLE 5-1						
U2	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U3	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U4	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U5	IC, TTL, QUAD, 2-INPUT POS-AND GATE	477539	01295	SN74S08N	1	1	
U6	IC, TTL, DUAL J-K EDGE TRIG, F/F	363440	01295	SN74S112N	2	1	
U7	IC, DUAL, "D" TYPE, EDGE TRIGGERED, F/F	418269	01295	SN74S74N	1	1	
U8	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U9	IC, TTL, MIS, QUAD, 2-LINE-TO-1-LINE	403576	01295	SN74157N	1	1	
U10	IC, LINEAR OP AMP	284760	12040	LM308	1	1	
U11	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U12	IC, POS NOR GATES, TOTEM POLE OUTPUTS	393041	01295	SN74LS02N	1	1	
U13	IC, TTL, DUAL J-K EDGE TRIG, F/F	363440	01295	SN74S112N	REF		
U14	IC, TTL, MSI, DECADE COUNTERS	293159	01295	SN7490AN	2	1	
U15	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U16Ⓐ	IC, TTL, MIS, QUAD "D" TYPE F/F W/CLEAR	355057	01295	SN74175N	1	1	
U17Ⓐ	IC, C-MOS, BCD TO 7-SEG LATCH/DECODER	429522	04713	MC14511CP	1	1	
U18Ⓐ	IC, C-MOS, HEX BUFFER/INVERTERS	381848	02735	CD4049UBE	2	1	
U19	IC, DUAL, 4-BIT DEDADE & BINARY COUNTERS	483594	01295	SN74LS390N	1	1	
U20Ⓐ	IC, MOS, COUNTER TIME BASE CIRCUIT	381822	50088	MK5009N	1	1	
U21Ⓐ	IC, C-MOS, DUAL, "D" TYPE, F/F	340117	02735	CD4013AE	3	1	
U22Ⓐ	IC, C-MOS, HEX BUFFER/INVERTERS	381848	02735	CD4049UBE	REF		
U23	IC, TTL, MSI, DECADE COUNTERS	293159	01295	SN7490AN	REF		
U24Ⓐ	IC, C-MOS, TRIPLE 3-INPUT OR GATES	408575	02735	CD4075BE	1	1	
U25Ⓐ	IC, MOS-TO-LED HEX DIGIT DRIVER	429506	12040	DS75492N	2	1	
U26Ⓐ	IC, C-MOS, QUAD, AND-OR SELECT GATE	419010	18324	CD4019AE/N4019A	1	1	
U27	IC, TTL, SCHMT, TRGGR, POS NAND GATES	483180	01295	SN74LS14N	1	1	
U28Ⓐ	IC, C-MOS 14-STAGE BINARY CNTR/DIVIDER	394486	02735	CD4020AE	1	1	
U29	IC, TTL, QUAD, 2-INPUT, POS, NAND GATE	393033	01295	SN74LS00N	1	1	
U30Ⓐ	IC, C-MOS, HEX BUFFER/INVERTER	381830	02735	CD4050AE	1	1	
U31Ⓐ	IC, C-MOS, NAND GATES, TRIPLE, 3-INPUT	375147	02735	CD4023A	1	1	
U32Ⓐ	IC, C-MOS, DECADE COUNTER/DIVIDER	403568	18725	CD4017AE	1	1	
U33Ⓐ	IC, C-MOS, QUAD, 2-INPUT NOR GATES	355172	02735	CD4001AE	1	1	
U34Ⓐ	IC, C-MOS, DUAL, "D" TYPE, F/F	340117	02735	CD4013AE	REF		
U35Ⓐ	IC, C-MOS, DUAL, "D" TYPE, F/F	340117	02735	CD4013AE	REF		
U36Ⓐ	IC, MOS-TO-LED HEX DIGIT DRIVER	429506	12040	DS75492N	REF		
U37Ⓐ	IC, COS/MOS, QUAD, BILATERAL SWITCH	363838	02735	CD4016AE	2	1	
U38Ⓐ	IC, COS/MOS, QUAD, BILATERAL SWITCH	363838	02735	CD4016AE	REF		
U39	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U40	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U41	SEE FINAL ASSEMBLY TABLE 5-1				REF		
U42	IC, LIN, 3-TERMINAL, NEG FIXED VOLT NEG	473819	07263	A79L12AWC	1	1	
U43	IC, LINEAR TIMER	402610	18324	NE555N	1	1	
XF2	SOCKET, FUSE	403642	00779	50863-8	4		

NOTE: Ⓐ Indicates the item can be damaged by static discharge.

Table 5-2. A1 Main PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
XF3	SOCKET, FUSE	403642	00779	50863-8	REF		
XU1	SOCKET, IC, 16-PIN DIP	370312	91506	316-AG39D	4		
XU2	SOCKET, IC, 16-PIN DIP	370312	91506	316-AG39D	REF		
XU3	SOCKET, IC, 8-PIN	478016	91506	308-AG39D	1		
XU8	SOCKET, IC, 16-PIN DIP	370312	91506	316-AG39D	REF		
XU11	SOCKET, IC, 16-PIN DIP	370312	91506	316-AG39D	REF		
XU15	SOCKET, IC, 40-PIN DIP	429282	09922	DILB40P-108	1		
XU39	SOCKET, XSTR	402958	09922	402958	3		
XU40	SOCKET, XSTR	402958	09922	402958	REF		
XU41	SOCKET, XSTR	402958	09922	402958	REF		

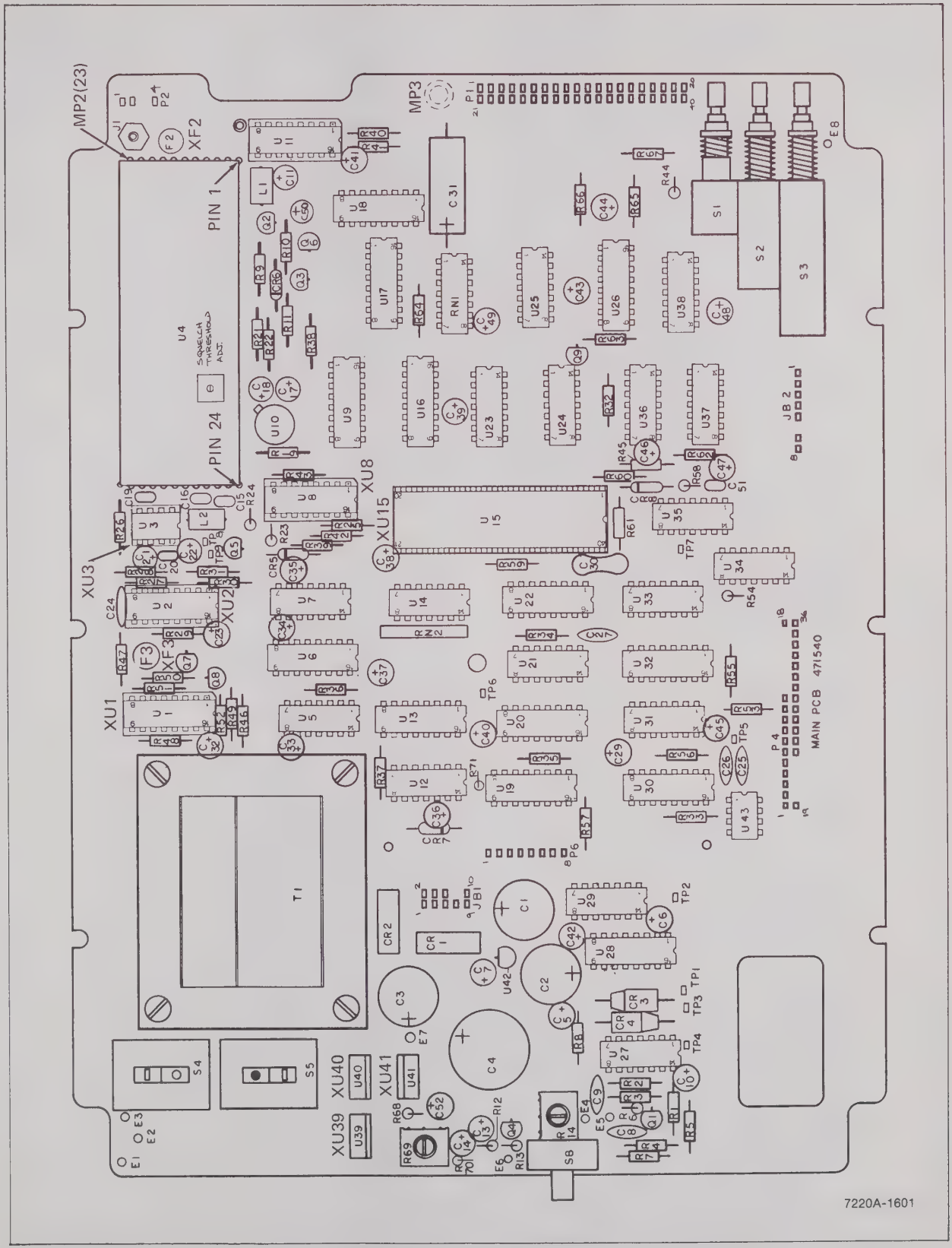


Figure 5-2. A1 Main PCB Assembly

Table 5-3. A2 Front Panel PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A2	FRONT PANEL PCB ASSEMBLY FIGURE 5-3 (7220A-4002T)	471516	89536	471516	1		
C1	CAP, MTL. FILM, .068 UF +/-20%, 250V	478651	25403	C281A/A68K	1		
C2	CAP, CER, 7.5K +/-0.25 PF, 1000V	519082	56289	561CCOJBA102AF7R5C	1		
C3	CAP, CER, 500 PF +/-10%, 1 KV	105692	71590	2DDH60N501K	1		
C4	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	4		
C5	CAP, CER, 100 PF +/-10%, 1 KV	105593	71590	DD-101	1		
C6	CAP, ELEC, 22 UF +/-20%, 16V	519074	56289	196D226X0016A1	1		
C7	CAP, CER, .001 UF +/-20%, 500V	402966	72982	8121-A100-W5R-102M	5		
C8	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X0006KA1	2		
C9	CAP, TA, 39 UF +/-20%, 6V	163915	56289	196D396X0006KA1	REF		
C10	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	REF		
C11	CAP, CER, .001 UF +/-20%, 500V	402966	72982	8121-A100-W5R-102M	REF		
C12	CAP, MICA, 390 PF +/-5%, 500V	148437	72136	DM15F391J	1		
C13	CAP, CER, .001 UF +/-20%, 500V	402966	72982	8121-A100-W5R-102M	REF		
C14	CAP, CER, 39 PF +/-2%, 1000V	519090	56289	561CCOJBA102AG390F	1		
C15	CAP, CER, .001 UF +/-20%, 500V	402966	72982	8121-A100-W5R-102M	REF		
C17	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	REF		
C18	CAP, TA, 10 UF +/-20%, 15V	193623	56289	196D106X0015A1	REF		
C19	CAP, CER, .001 UF +/-20%, 500V	402966	72982	8121-A100-W5R-102M	REF		
CR1	DIODE, SI, LOW CAP, 250 MW	523746	07263	FJT 1138	2	1	
CR2	DIODE, SI, LOW CAP, 250 MW	523746	07263	FJT 1138	REF		
DS1	DISPLAY LED	477562	89536	477562	9	2	
DS2	DISPLAY LED	477562	89536	477562	REF		
DS3	DISPLAY LED	477562	89536	477562	REF		
DS4	DISPLAY LED	477562	89536	477562	REF		
DS5	DISPLAY LED	477562	89536	477562	REF		
DS6	DISPLAY LED	477562	89536	477562	REF		
DS7	DISPLAY LED	477562	89536	477562	REF		
DS8	DISPLAY LED	477562	89536	477562	REF		
DS9	DISPLAY LED	477562	89536	477562	REF		
DS10	DIODE, LIGHT EMMITING	483420	28480	HLMP6203	1	1	
DS11	DIODE, LIGHT EMMITING	483420	28480	HLMP6203	REF		
DS12	DIODE, LIGHT EMMITING	483420	28480	HLMP6203	REF		
H1	SCREW, PHP, 2-28 X .406	493957	89536	493957	8		
J1	CONNECTOR	460030	22526	65000-220	1		
J2	CONNECTOR, RECEPTACLE	375329	00779	85863-3	3		
L1	CHOKE, 6-TURN	320911	89536	320911	1		
MP1	ACTUATOR (S1, S2, & S3)	454371	00779	435995	3		
MP2	CARRIER	477976	00779	435999-9	2		
MP3	CONNECTOR, COAXIAL	479162	24931	28JR175	1		
MP4	DETENT SPRING	472878	00779	435996	3		
MP5	SPACER, LED	426882	89536	426882	1		
MP6	TEST JACK(ON CIRCUIT SIDE, NOT SHOWN)	149112	74970	105-0753	1		
MP7	WIPER GUIDE	472886	00779	435998	3		
Q1	XSTR, J-FET, N-CHANNEL	288324	89536	288324	1	1	
Q2	XSTR, SI, NPN	218396	04713	2N3904	1	1	
R1	RES, COMP, 910K +/-5%, 1/4W	285338	01121	CB9115	1		
R2	RES, COMP, 100K, +/-5%, 1/4W	148189	01121	CB1045	1		
R3	RES, COMP, 220K +/-5%, 1/2W	109025	01121	CB2215	1		

Table 5-3. A2 Front Panel PCB Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R4	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R5	RES, DEP. CAR, 12K +/-5%, 1/4W	348847	80031	CR251-4-5P12K	1		
R6	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	1		
R7	RES, MTL. FILM, 1.5K +/-1%, 1/8W	313098	91637	CMF55152F	2		
R8	RES, MTL. FILM, 1.5K +/-1%, 1/8W	313098	91637	CMF55152F	REF		
R9	RES, DEP. CAR, 470K +/-5%, 1/4W	342634	80031	CR251-4-5P470K	1		
R10	RES, VAR, 25K +/-10%, 1/2W	289678	11236	360S253A	1	1	
R11	RES, VAR, CERMET, 5K +/-20%, 1/2W	226084	80031	ET50W02	1	1	
R12	RES, VAR, 25K +/-30%, 1/4W	485664	89536	485664	1	1	
R13	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	2		
R14	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	REF		
R15	RES, DEP. CAR, 180 +/-5%, 1/4W	441436	80031	CR251-4-5P180E	1		
R17	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	2		
R18	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	REF		
RN1	RESISTOR NETWORK, 10K +/-2%, 1/8W	412924	89536	412924	1		
RN2	RESISTOR NETWORK, 10K +/-2%, 1/8W	414003	89536	414003	1		
U1	IC, ANALOG BI-POLAR DC COUP WIDEBAND AMP	429191	89536	429191	1	1	
U2	IC, LIN, 3-TERMINAL NEG FIXED VOLT REG	454793	04713	MC79L05ACP	1	1	
XU1	SOCKET, I.C.	413229	01295	C 93102	1		

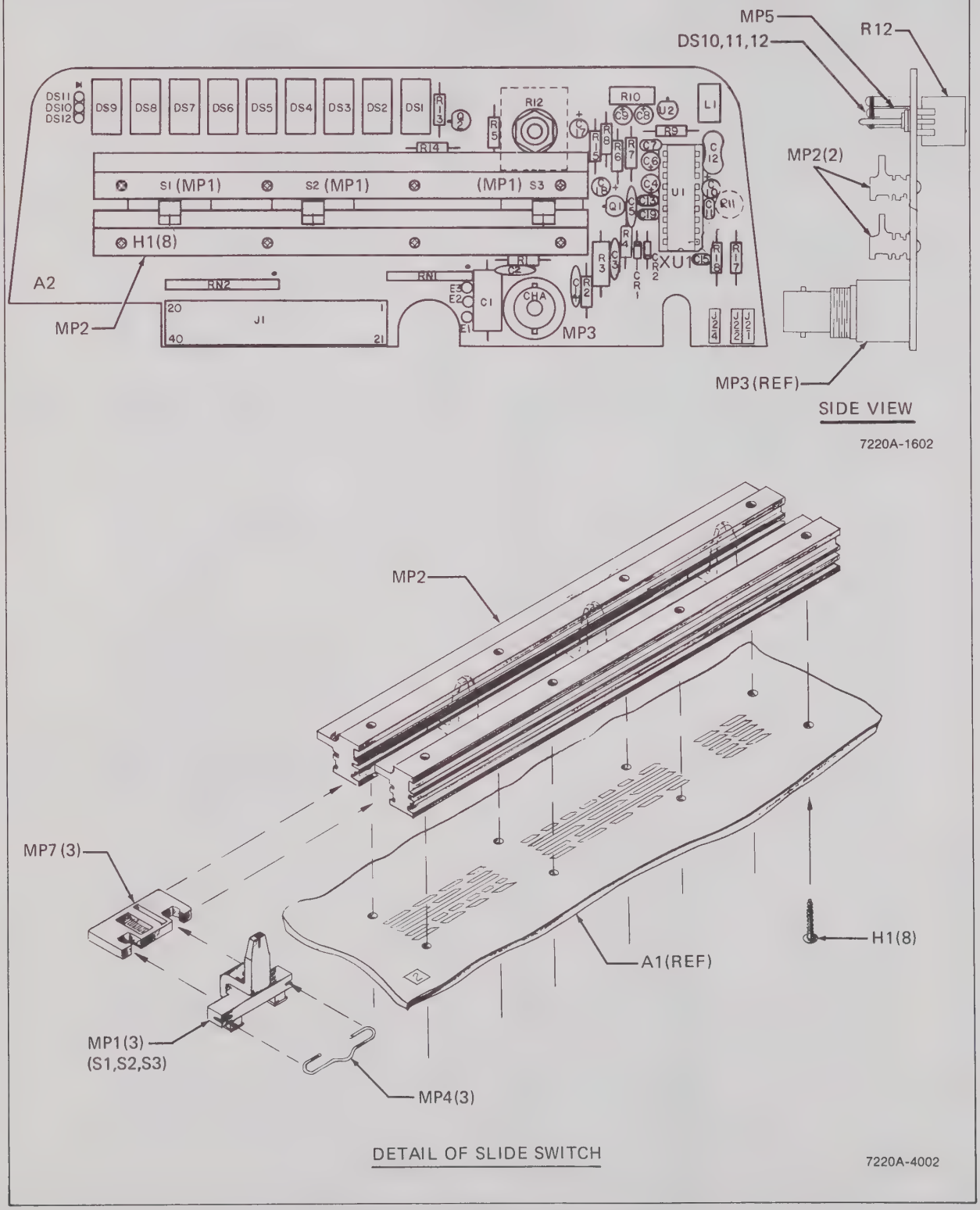
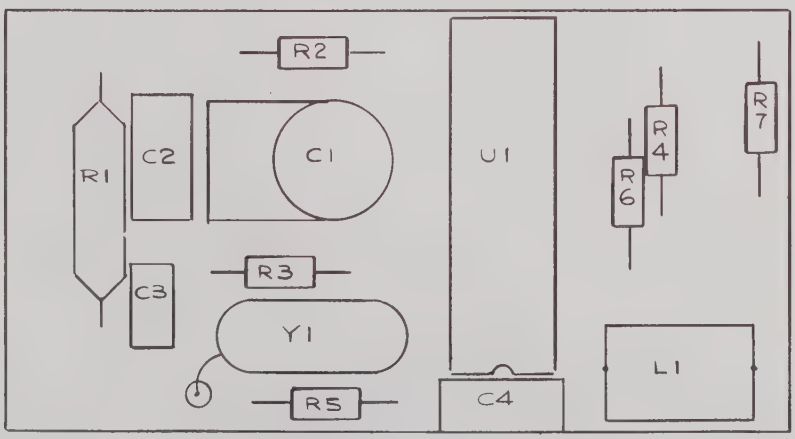


Figure 5-3. A2 Front Panel PCB Assembly

Table 5-4. A3 Timebase PCB Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
A3	TIMEBASE PCB ASSEMBLY FIGURE 5-4 (7220A-4009T)	538660	89536	538660	REF		
C1	CAP, MINIATURE TRIMMER, 1.5-14 UF, 250V	543520	91293	8091	1		
C2	CAP, CER, 22 PF +/-5%, 100V	448449	80031	2222-638-10229	1		
C3	CAP, CER, 0.01 UF +/-20%, 100V	407361	72982	8121-A100-W5R-103M	1		
C4	CAP, CER, 0.22 UF +/-20%, 50V	309849	71590	CW30C224K	1		
L1	CHOKE, 6-TURN	320911	89536	320911	1		
MP1	PINS, CONTACT (NOT SHOWN)	376574	00779	3-87022-1	5		
R1	RES, MTL. FILM, 47.5 +/-1%, 1/8W	306076	91637	CMF5547R5F	1		
R2	RES, COMP, 560 +/-5%, 1/8W	115303	01121	BB5615	5		
R3	RES, COMP, 1K +/-5%, 1/8W	153916	01121	BB1025	1		
R4	RES, COMP, 560 +/-5%, 1/8W	115303	01121	BB5615	REF		
R5	RES, COMP, 560 +/-5%, 1/8W	115303	01121	BB5615	REF		
R6	RES, COMP, 560 +/-5%, 1/8W	115303	01121	BB5615	REF		
R7	RES, COMP, 560 +/-5%, 1/8W	115303	01121	BB5615	REF		
U1	IC, ECL, DUAL 4-5 INPUT OR/NOR GATE	454967	04713	MC10109P	1	1	
Y1	CRYSTAL, QUARTZ	385732	89536	385732	1		



7220A-1609

Figure 5-4. A3 Timebase PCB Assembly

Section 6
Option & Accessory Information

TABLE OF CONTENTS

OPTION/ MODEL NO.	DESCRIPTION	PAGE
	ACCESSORIES	600-1
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72XXA-010	Battery Pack	010-1
7220A-111	1 PPM TCXO	111-1
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7220A-351	Resolution Multiplier	351-1
72XXA-521	Printer Interface	521-1

6-1. INTRODUCTION

6-2. This section of the manual contains information about options and accessories available for use with the 7220A. Where applicable, these descriptions will include the same kind of information as presented in Sections 1-5 of this manual (specifications, installation, theory of operation, etc.). Schematic diagrams for any appropriate option or accessory may be found in Section 8.

6-3. Accessory information can be identified with "600-" paragraph numbers. For options, relevant page and paragraph numbers contain the option number.

Accessories

600-1. ACCESSORIES

600-2. Ordering Information

600-3. When appropriate, installation instructions are included with each accessory ordered. Be sure to include the accessory model number when ordering.

600-4. Rack and Panel Adapters

600-5. Mounting kits may be ordered to adapt the standard 7220A PTI-style size C instrument case to either rack or panel mounting. Each kit includes all mounting hardware. Model Y2014 allows one 7220A case to be mounted in a 19-inch rack, and Model Y2015 allows two 7220A cases to be mounted in a 19-inch rack. Model Y2020 allows one 7220A case to be panel-mounted.

600-6. Instrument Cables

600-7. Two instrument ribbon cables are available for connecting the Digital Interface Option -521 to the Interface PCB Assembly Option -522, which is mounted in the 1120A IEEE-488 Translator. The cables are identical in function and differ only in length. Cable Y7203 is 2 feet in length, and cable Y7204 is 5 feet in length. Cable Y7203 is supplied with Options -521 or -529.

600-8. Whip Antenna

600-9. The A53 Whip Antenna allows the 7220A to make RF measurements via the antenna rather than cable connection. The Whip Antenna attaches directly to the 7220A front panel Channel A or Channel B input BNC connectors, and can be swiveled or extended for easy positioning.

Table 600-1. 7220A Accessories

MODEL NO.	DESCRIPTION
Y2014	Single mount 19 inch rack
Y2015	Dual mount 19 inch rack
Y2020	Single mount panel
Y7203	2 foot connecting cable
Y7204	5 foot connecting cable
A53	Extendable whip antenna

Option -010
Battery Pack

010-1. INTRODUCTION

010-2. Option -010 is a nickel-cadmium rechargeable battery unit. The option uses "F" cell nicad batteries for a total capacity of 5.6 amp hours. With a completely discharged battery, charge time is a minimum of 16 hours at room temperature. A discharge cut-off relay has been incorporated to guard against discharging the nicads to too low a level. A thermistor sensor circuit monitors battery temperature and halts the charging if the battery gets too hot. The battery output is fused to protect it against short circuits. Housed in a separate plastic box to eliminate acid corrosion problems, the battery assembly is attached inside the top cover. This option can be installed in the field. Order kit number 72XXA-010K.

010-3. SPECIFICATIONS

010-4. Specifications for the -010 Battery Option are listed in Table 010-1.

010-5. INSTALLATION

010-6. Use the following procedure to install the -010 Battery Option. Refer to Figure 010-1 for installation instructions. Component location can also be determined using Figures 010-3 and 010-4.

1. Remove line power from the instrument.

2. Remove the top cover using the procedure described in Section 4.

3. Place the battery assembly so that the battery and Battery Option PCB are closer to the front of the instrument and the two instrument handle hold-down bolts are through the corresponding holes on the battery bracket.

4. Place the two nuts on the instrument handle hold-down bolts and tighten.

5. Remove the bottom cover using the procedure described in Section 4. Do not remove the Front or Rear Panel assemblies from the Main PCB.

6. Locate solder bridge SB1 near the BTRY/LINE switch on the bottom of the Main PCB. (For 7220A, SB1 is on the front left corner of the bottom of the main PCB). Remove the short. In addition, remove the short on SB6 for the 7261A only.

7. Install the bottom cover.

8. Plug the two cables from the Battery Option PCB into their appropriate connectors on the Main PCB. Grey plug to JB1, black plug to JB2.

9. Fasten the grey ribbon cable under the grey retaining clip (located on the bottom side of the instrument's top cover).

10. Install the top cover of the instrument.

Table 010-1. Specifications

Capacity	5.6 Ampere hours
Battery Type	Four size "F" nicad cells
Charge Time	16 hours minimum at room temperature
Charge Protection	Thermistor actuated shut down of charging circuit if battery gets near 65°C
Discharge Protection	Low voltage automatic shut down at about +4V to prevent battery discharging to a reversed cell condition.

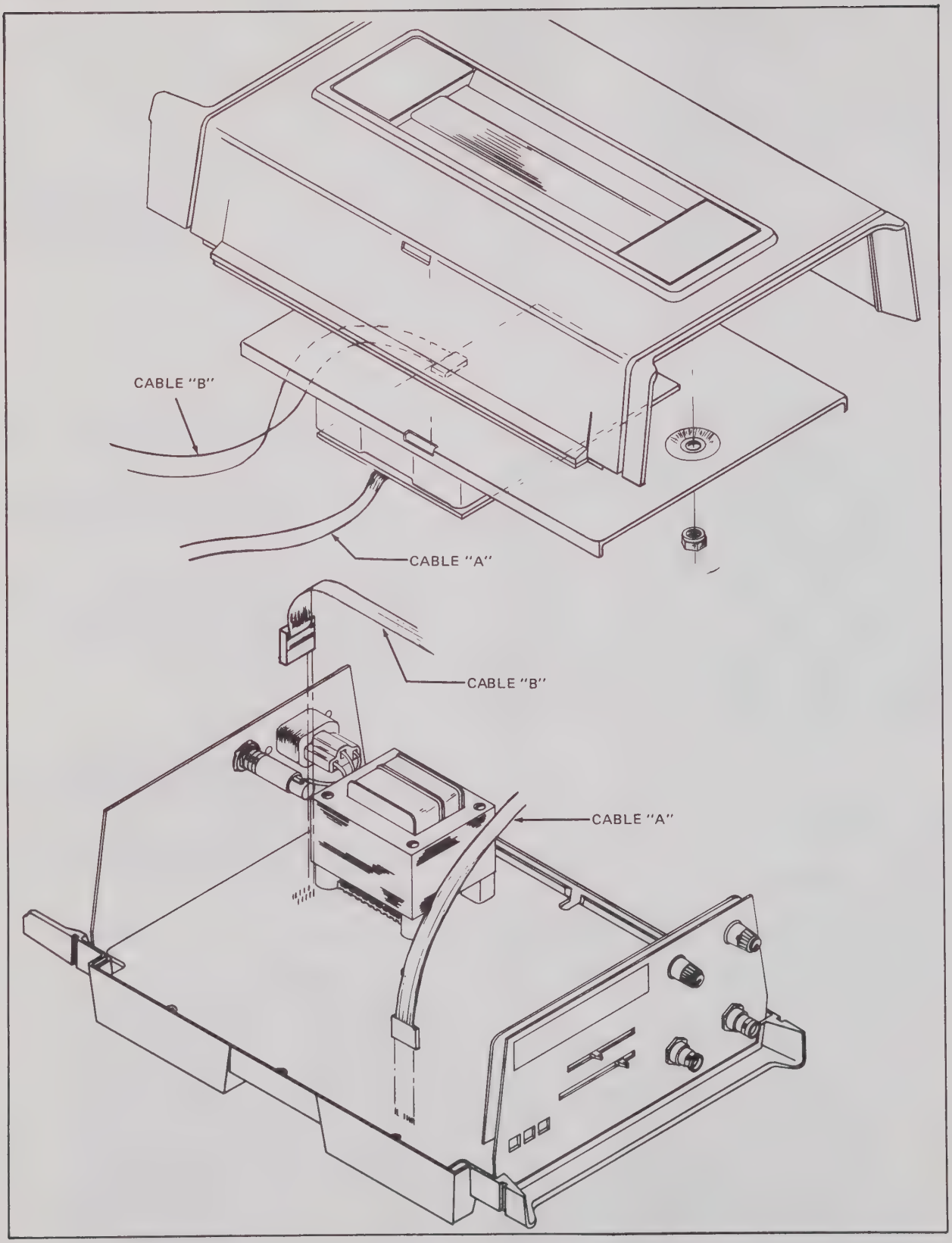


Figure 010-1. Installation

010-7. OPERATION

010-8. To use the battery for instrument power, set the BTRY/LINE switch to the BTRY position. The ON/STBY switch functions normally. The instrument may be powered from the battery with the line cord plugged into line power. This serves no useful purpose, however, and discharges the battery needlessly. When the battery has discharged to about 4V, the low battery voltage relay will remove the instrument load from the battery output, preventing the battery from discharging to too low a level. Place the two POWER switches in the STBY and LINE positions to recharge the battery. After the battery has been charged sufficiently, the RESET switch on the instrument front panel must be pressed to unlatch the low voltage relay and restore normal battery operation.

010-9. If neither oven time base option is installed, the battery will recharge any time the instrument is connected to line power and the power control is set to STBY. The charge rate is maximum when the ON/STBY switch is in the STBY position, and the BTRY/LINE switch is in the LINE position. If the battery is discharged completely, this charge rate will recharge the battery in 16 hours at temperatures around 22°C (72°F). If either oven time base is installed, the BTRY/LINE switch determines which source will power the oven. For maximum charge, the switch must be in the LINE position and the ON/STBY switch must be in the STBY position. If the BTRY/LINE switch is in the BTRY position and the ON/STBY switch is in the STBY position, the oven will draw about 200 mA of the 560 mA charging current. Under these conditions, the battery may not charge completely. If the POWER switches are in the ON and LINE positions, the charging rate will be reduced to prevent overheating inside the instrument. This charge rate is insufficient to recharge the battery but will maintain a float charge on the battery. The thermocouple sensor will halt the charge to keep the battery temperature from exceeding 65°C (149°F). (This will only occur in high ambient temperature environments.) The battery charge will automatically resume when the battery has cooled enough.

NOTE

Battery manufacturers recommend that nicad batteries should not be stored for extended periods of time without recharging at least every 90 days. Storage temperature below 25° C (77° F) is recommended.

010-10. THEORY OF OPERATION

010-11. The theory of operation for the -010 Option will be divided into a basic functional description of the major circuits of the option and a detailed circuit analysis of each circuit.

010-12. BASIC FUNCTIONAL DESCRIPTION

010-13. As Figure 010-2 shows, there are four main sections to the Battery Option PCB circuitry. The Current Source uses +5V unregulated power from the Main PCB to provide the charging current for the battery. The charging rate (high or low) is determined by the position of the ON/STBY switch. The Battery Hi-Temp Circuit reduces the charging current if the battery temperature approaches 65°C. The Low Battery Voltage Relay circuit normally passes the battery power on to the BTRY/LINE switch. Should the battery voltage drop to around 4V, the relay contacts will open, removing the load from the battery. The RESET switch on the instrument front panel must be pressed to restore the Low Battery Voltage Relay Circuit. If the BTRY/LINE switch is in the BTRY position, the +5V power from the battery is connected to the ON/STBY switch, and the oven if an oven time base is installed. If the ON/STBY switch is in the ON position, the battery power is supplied to the instrument and the Inverter circuit. The Inverter circuit provides operating voltages for the -5V, +12V and -12V regulators.

010-14. DETAILED CIRCUIT ANALYSIS

010-15. The Battery Option Schematic in Section 8 will be used to illustrate the detailed circuit analysis. The battery and thermistor are located inside the battery case.

010-16. Battery Hi-Temp Circuit

010-17. The Battery Hi-Temp Circuit is an inverting amplifier that protects the battery by reducing the battery charging current as the battery temperature approaches 65°C. It does this by altering the bias voltage of the Current Source controller to turn off the current source. The inverting amplifier is U1B with thermistor RT1 used as the feedback resistor. The positive input of the op amp is COMMON. The negative input is the -12V coupled through R9. RT1 is located next to the battery. When the battery is about 22°C, the resistance of RT1 will be about 50Ω. At this time, the output of the inverting amplifier (felt at the lower junction of R7 and R8) is about +.4V. RT1 exhibits a positive temperature coefficient. As the battery temperature rises, the resistance of RT1 increases. When the battery temperature approaches 65°C, the resistance of RT1 passes over a sharp knee and approaches 500Ω. The output of the negative gain amplifier approaches +5V.

010-18. Current Source

010-19. The Current Source uses the unregulated +5V from the Main PCB to provide charging current for the

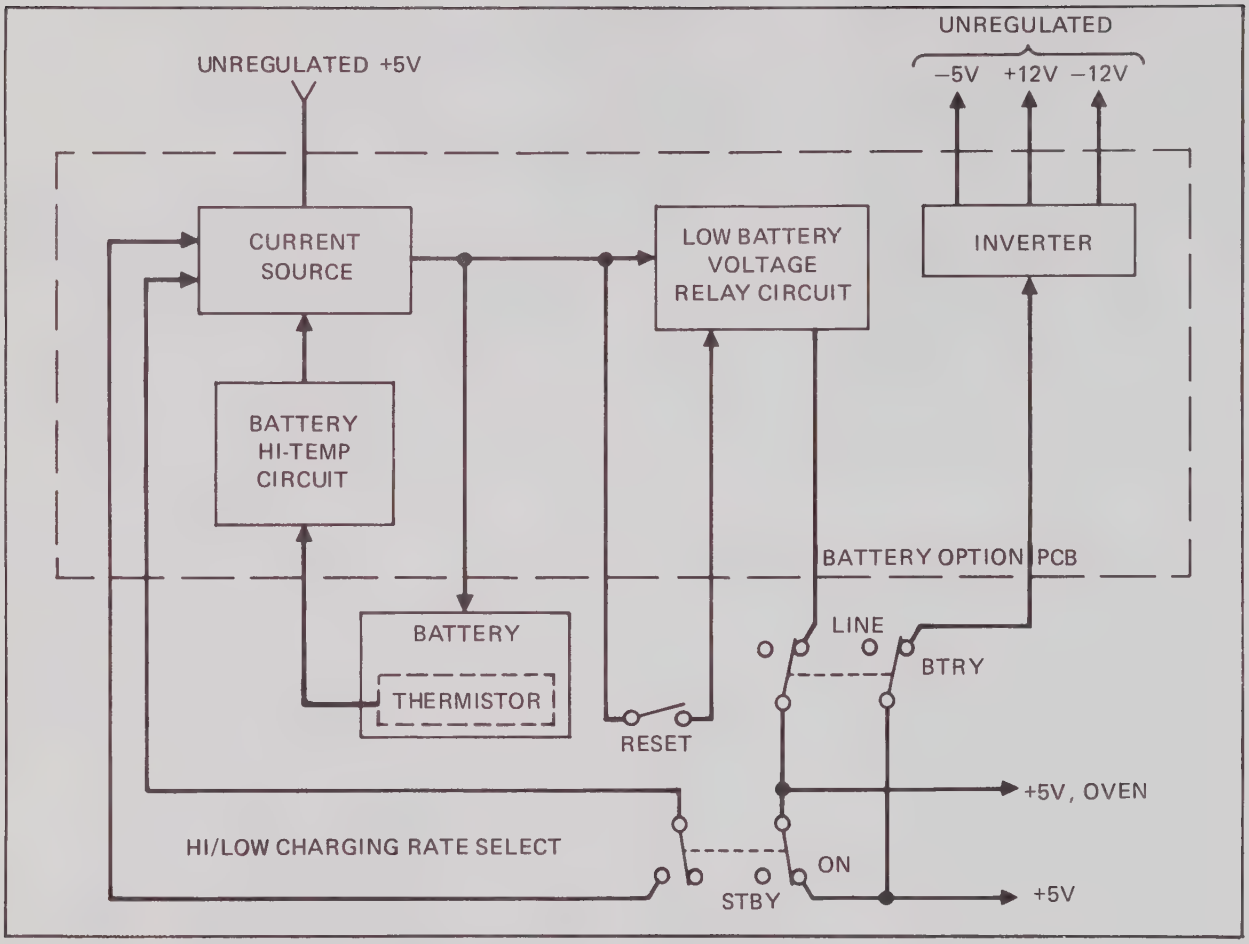


Figure 010-2. -010 Option Block Diagram

battery. This circuit consists of the series pass element, Q1; the sensing element, R1; the control element, U1A; and their associated circuitry. Q1 directly controls the current charging the battery. The base bias of Q1 is in turn controlled by the output of U1A. The positive input is battery voltage felt on the battery side of R1 (TP2). The negative input is picked off the voltage divider network composed of R2, R8 and sometimes R7. The voltage divider is between the input side of R1 (TP1) and the output of the Battery Hi-Temp circuit.

010-20. The charging current is changed by altering the input to U1A from the voltage divider. The voltage divided input is altered by changing the position of the ON/STBY switch. When the switch is in the STBY position, R7 is placed in parallel with R8. Their combined resistance is about one-fifth that of R8 alone. At normal operating temperatures, the bottom of the voltage divider is at +0.5V and the top is at battery voltage plus the voltage drop across R1. The op amp causes Q1 to pass nominally 560 mA through R1. If the ON/STBY switch is in the ON position, R7 is no longer in parallel with R8. This change in the voltage divider input to U1A will cause the charging current to decrease to nominally 110 mA. If the battery temperature approaches 65° C, the bottom of the voltage divider becomes +5V and the voltage at TP1 approaches the battery voltage. This decreases the output of the op amp cutting off Q1. As the battery cools, the resistance of the thermistor decreases allowing the battery charge to resume. If F1 blows, removing the regulated input to U1A, CR10 will limit the conduction of Q1 so that the voltage at TP2 does not exceed 6V.

010-21. Low Battery Voltage Relay Circuit

010-22. The low battery voltage relay keeps the battery from discharging to a reversed cell condition by removing the battery load when battery voltage drops to about 4V. The battery is connected to its load through K1, a two coil latching relay. During normal operation, the battery and its load are connected, Q2 and Q6 are off and Q5 is in saturation. When battery voltage drops to about 4V, the base bias on Q5 (TP5) is low enough to cut Q5 off. This lets the input on pin 13 of flip-flop U2 rise. This will

change the state of U2 making the output on pin 11 of U2 go low. This causes Q6 to conduct, charging C2 and turning Q2 on. When Q2 conducts, the coil of K1 in the collector of Q2 will energize, opening K1. When K1 removes the battery loads, the input circuitry for Q2 is deenergized. C2 has been charged to make Q2 conduct long enough to insure that K1 is latched in the open condition. After the battery has been recharged, pressing the RESET switch on the front panel will connect battery voltage to both the reset coil of K1 and pin 6 of U2. The RESET switch contacts will be closed long enough to insure that K1 will be latched shut. This will restore the connection between the battery and its load. Q5 will go into saturation. The battery voltage at pin 6 of U2 will cause pin 11 to go high, turning off Q6.

010-23. Inverter

010-24. The Inverter is composed of Q3, Q4, T1 and their associated circuitry. The three components form an oscillator that runs at about 10 kHz. This oscillation allows T1 to step up the battery voltage to provide rectified operating voltages to the –5V, +12V and –12V regulators for instrument power.

010-25. PERFORMANCE TEST

010-26. Use the following procedure as a performance test. Table 010-2 lists the test points. The component location diagram at the end of this option can be used to locate these test points. The instrument will be referred to as the UUT (Unit Under Test). Use a variable DC power supply with an output range of at least 3-5V and the test equipment listed in Section 4.

1. Remove the top cover of the UUT using the procedure given in Section 4. Leave the cables from the Battery Option PCB connected to the Main PCB and lay the top cover beside the instrument, upside-down. The grey ribbon cable will have to be removed from the retaining clip on the bottom side of the top cover.

Table 010-2. Test Points

TEST POINTS	COMMENTS
TP1, TP2	Voltage across sensing resistor, R1.
TP3	COMMON
TP4	Battery voltage.
TP5	Low Battery Voltage Sensing Point
TP6	Low Battery Voltage Cut-Off Signal.

2. Connect the UUT to line power.

3. On the UUT front panel:

   a. Set the ON/STBY switch to the STBY position.

   b. Set the BTRY/LINE switch to the LINE position.

4. Connect the DVM: + to TP2, - to TP3.

5. Verify that the DVM reads greater than 5V. If it does not, continue the charge until this reading (Battery Voltage) is at least 5V.

NOTE

In the next step, the DVM test leads must be isolated from ground.

6. Connect the DVM: + to TP1, - to TP2.

7. Verify that the DVM reads between 96 mV and 128 mV.

8. Set the ON/STBY switch to ON.

9. Verify that the DVM reads between 14 mV and 30 mV.

10. Set the ON/STBY switch to STBY.

11. Connect the DVM: + to TP4, - to TP3.

12. Verify that the DVM reads battery voltage. If there is no voltage present, press the RESET switch on the front panel. The DVM should now read battery voltage.

CAUTION

Counter must be disconnected from ground during the following soldering procedures. Disconnect the power cord and any other connection (e.g., BNC) that may be introducing a ground to the instrument.

13. Unsolder an end of the fuse wire located on the PCB near the battery harness.

14. Adjust the DC Power Supply for a +5V output.

15. Connect the DC Power Supply + to TP2, - to TP3.

16. Connect the DVM + lead to TP4, – lead to ground.

17. Slowly reduce the DC Power Supply voltage until the relay opens as indicated by the voltage of TP4 dropping suddenly to 0V. (The click of the relay may also be heard.)

18. Verify that the output voltage of the DC Power Supply is between +3.8V and +4.3V.

19. Disconnect the DC Power Supply. Resolder the fuse wire.

20. On the front panel of the UUT:

a. Press and release the RESET switch.

b. Set the ON/STBY switch to the ON position.

c. Set BTRY/LINE switch to the BTRY position.

d. Set the RESOLUTION switch to the 1 kHz position. (For 7220A, 100 Hz.)

e. Set the function select switch to the CHK position.

21. Verify that the UUT display reads 10.000. (For 7220A, display should read 10.0000.)

010-27. MAINTENANCE

010-28. Battery Replacement

010-29. Use the following procedure to replace the battery:

1. Remove the line power from the instrument.

2. Remove the top cover of the instrument using the procedure given in Section 4. Place the top cover upside-down on the work surface.

3. Disconnect the two cables between the Battery PCB and the Main PCB.

4. Remove the four screws holding the battery case to the battery bracket.

5. Note the position of the thermistor. This will be important in a later step.

6. Lift the battery case and Battery Option PCB off the battery and place it to one side.

7. Unsolder the two wires connected to the battery (white and black).

8. Dispose of the old battery.

9. Solder the white and black wires to the tabs on the new battery. White to the tab on the recessed battery end (+) and black to the tab on the flush battery end (-).

10. Replace the battery case being sure to place the thermistor in the same position noted in step 5.

11. Connect the two cables between the Battery PCB and the Main PCB.

12. Replace the top cover.

010-30. Fuse Replacement

010-31. Use the following procedure to replace the fuse on the Battery Option PCB:

1. Remove the line power from the instrument.

2. Remove the top cover from the instrument using the procedure given in Section 4. Place the top cover upside-down on the work surface.

3. Unsolder the ends of F1 from its terminals.

4. Solder a suitable length of #35 magnet wire between the fuse terminals.

5. Place the top cover on the instrument.

010-32. LIST OF REPLACEABLE PARTS

010-33. Table 010-3 is a list of replaceable parts for the battery assembly. Figure 010-3 is the component location diagram for this table.

Table 010-3. Battery Option -010 Assembly

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	⊗ BATTERY OPTION-010 ASSEMBLY FIGURE 6010-3 (7220A-4010T)	OPTION	-010		1		
	BATTERY PCB ASSY	ORDER	BY	OPTION -010	REF		
BT1	BATTERY ASSY	484048	89536	484048	1		
C1	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	6		
C2	CAP, TA, 4.7 UF +/-20%, 25V	161943	56289	196D475X0025KA1	1		
C3	CAP, TA, 330 UF, +/-10%, 6V	193011	56289	150D337X9006S	1		
C4	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C5	CAP, CER, 47 PF +/-20%, 1000V	369132	56289	C030B102H470J	1		
C6	CAP, CER, 0.1 UF +/-GVM, 25V	369199	71590	UK-25-104	1		
C7	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C8	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C9	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
C10	CAP, TA, 2.2 UF +/-20%, 20V	161927	56289	196D225X0020HA1	REF		
CR1	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	9	2	
CR2	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR3	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR4	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR5	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR6	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR7	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR8	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR9	DIODE, SI, HI-SPEED SWITCH	203323	07910	1N4448	REF		
CR10	DIODE, ZENER, 7.5V	256446	07910	1N755B	1		
H1	NUT, HEX, #4	147611	89536	147611	2		
H2	SCREW, PHP, 4-40 X 1/4	129890	73734	19022	1		
H3	SCREW, PHP, 6-32 X 1/4	152140	73734	19042	8		
H4	SCREW, RHD, PH, 4-40 X 3/8	152124	73734	18024	2		
H5	SPACER	500074	89536	500074	4		
H6	WASHER, FLAT #8	110288	73734	97425	4		
H7	WASHER, FIBER	246488	73734	1471	4		
H8	WASHER, #6	110338	89536	110338	8		
H9	WASHER, #6	152140	89536	152140	4		
H10	WASHER, LOCK #4	110403	73734	1302	2		
H11	WASHER, SHOULDER, INSULATING	485417	86928	5607-50	1		
H12	WASHER, SPLIT #4	110395	89536	110395	1		
K1	RELAY, LATCHING	484535	89536	484535	1		
L1	CHOKE	502138	89536	502138	1		
MP1	BRACKET, BATTERY	476200	89536	476200	1		
MP2	CASE, BATTERY	475459	89536	475459	1		
MP3	CABLE TIE	172080	06383	SST-1M	1		
MP4	INSULATOR, REG.	412809	13103	43-77-8	1		
MP5	PLUG, CONNECTOR KEY (NOT SHOWN)	500801	52152	3435-0000	1		
MP6	SPACER, PCB COMPONENT (NOT SHOWN)	296319	89536	296319	1		
MP7	SPACER, XSTR (TO Q2) (NOT SHOWN)	152207	07047	10123-DAP	1		
Q1	TRANSISTOR, SI, NPN, PWR	325761	09214	D44C5	1	1	
Q2	XSTR, SI, NPN	346916	89536	346916	1	1	
Q3	XSTR, SI, NPN, PWR	325720	04713	MJE3055	2	1	
Q4	XSTR, SI, NPN, PWR	325720	04713	MJE3055	REF		

Table 010-3. Battery Option -010 Assembly (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
Q5	XSTR, SI, NPN	218396	04713	2N3904	1	1	
Q6	XSTR, SI, PNP	195974	04713	2N3906	1	1	
R1	RES, WW, 0.2 +/-3%, 0.7W	255661	89536	255661	1		
R2	RES, MTL. FILM, 1.1K +/-1%, 1/8W	241497	91637	CMF551101F	1		
R4	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR251-4-5P100K	1		
R5	RES, MTL. FILM, 86.6K +/-1%, 1/8W	291468	91637	CMF558661F	1		
R6	RES, DEP. CAR, 47 +/-5%, 1/4W	441592	80031	CR251-4-5P47E	2		
R7	RES, MTL. FILM, 61.9K +/-1%, 1/8W	237230	91637	CMF556191F	1		
R8	RES, MTL. FILM, 249K +/-1%, 1/8W	268805	91637	CMF552493F	1		
R9	RES, DEP. CAR, 1.2K +/-5%, 1/4W	441378	80031	CR251-4-5P1K2	1		
R10	RES, DEP. CAR, 47 +/-5%, 1/4W	441592	80031	CR251-4-5P47E	REF		
R11	RES, COMP, 10 +/-5%, 1W	166298	01121	GB1005	1		
R12	RES, DEP. CAR, 330 +/-5%, 1/4W	368720	80031	CR251-4-5P330E	1		
R13	RES, DEP. CAR, 82 +/-5%, 1/4W	442277	80031	CR251-4-5P82E	1		
R14	RES, MTL. FILM, 10K +/-1%, 1/8W	168260	91637	CMF551002F	1		
R15	RES, MTL. FILM, 6.65K +/-1%, 1/8W	294918	91637	CMF556651F	1		
R16	RES, THERMISTOR, 10K +/-10%, 3 MW	104596	15801	JA41J1			
R17	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R18	RES, DEP. CAR, 470 +/-5%, 1/4W	343434	80031	CR251-4-5P470E	1		
T1	XFMR, POWER	486530	89536	486530	1		
U1	IC, LINEAR OP AMP	414284	12040	LM1458N	1	1	
U2Ⓢ	IC, COS/MOS, NOR GATES, POS LOGIC	355172	02735	CD4001AE	1	1	
W1	CABLE, BATTERY #1	488403	89536	488403	1		
W2	CABLE, BATTERY #2	488411	89536	488411	1		
W3	CABLE, BATTERY #3	491704	89536	491704	1		

NOTE: Ⓢ **Indicates the item can be damaged by static discharge.**

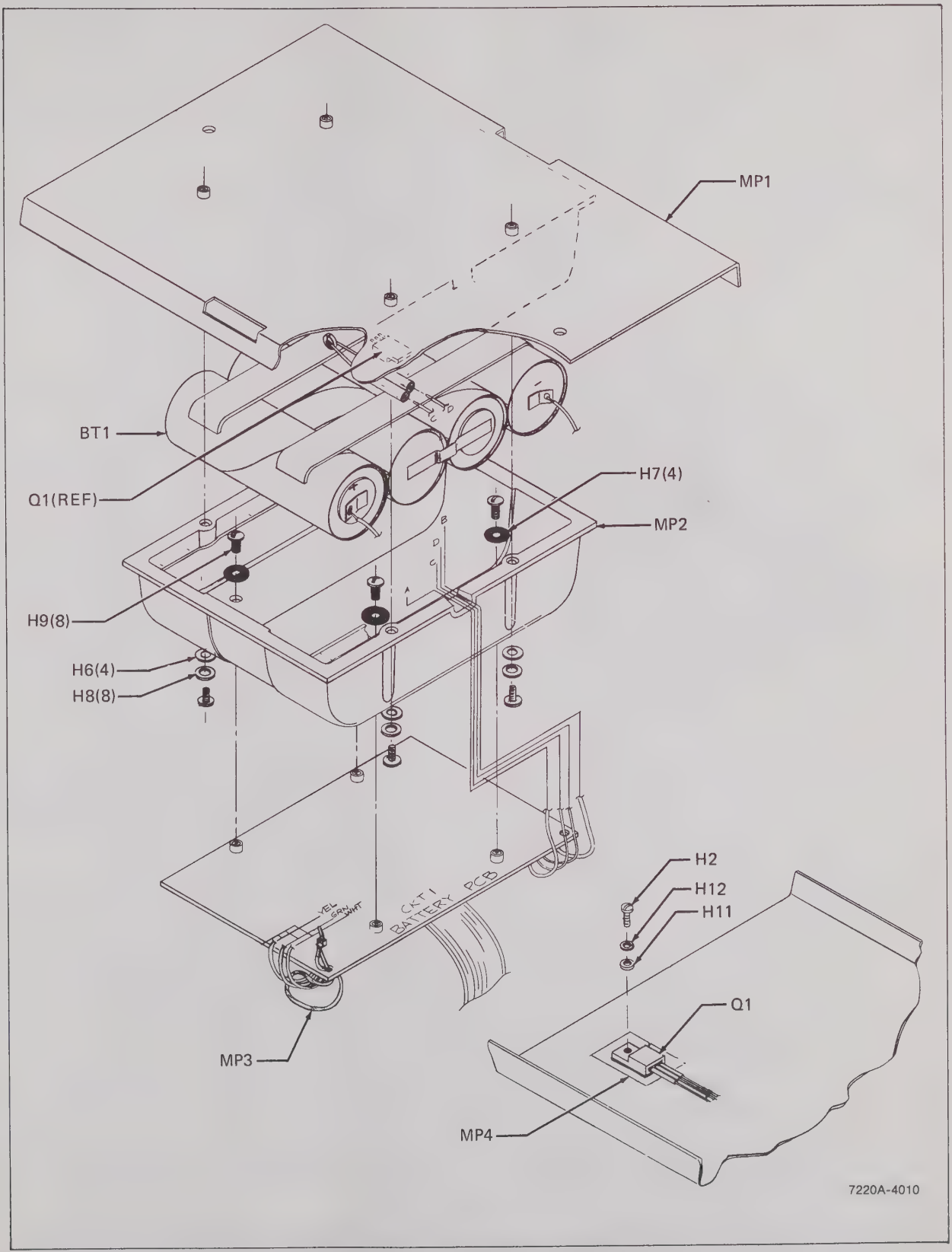


Figure 010-3. Battery Option -010 Assembly

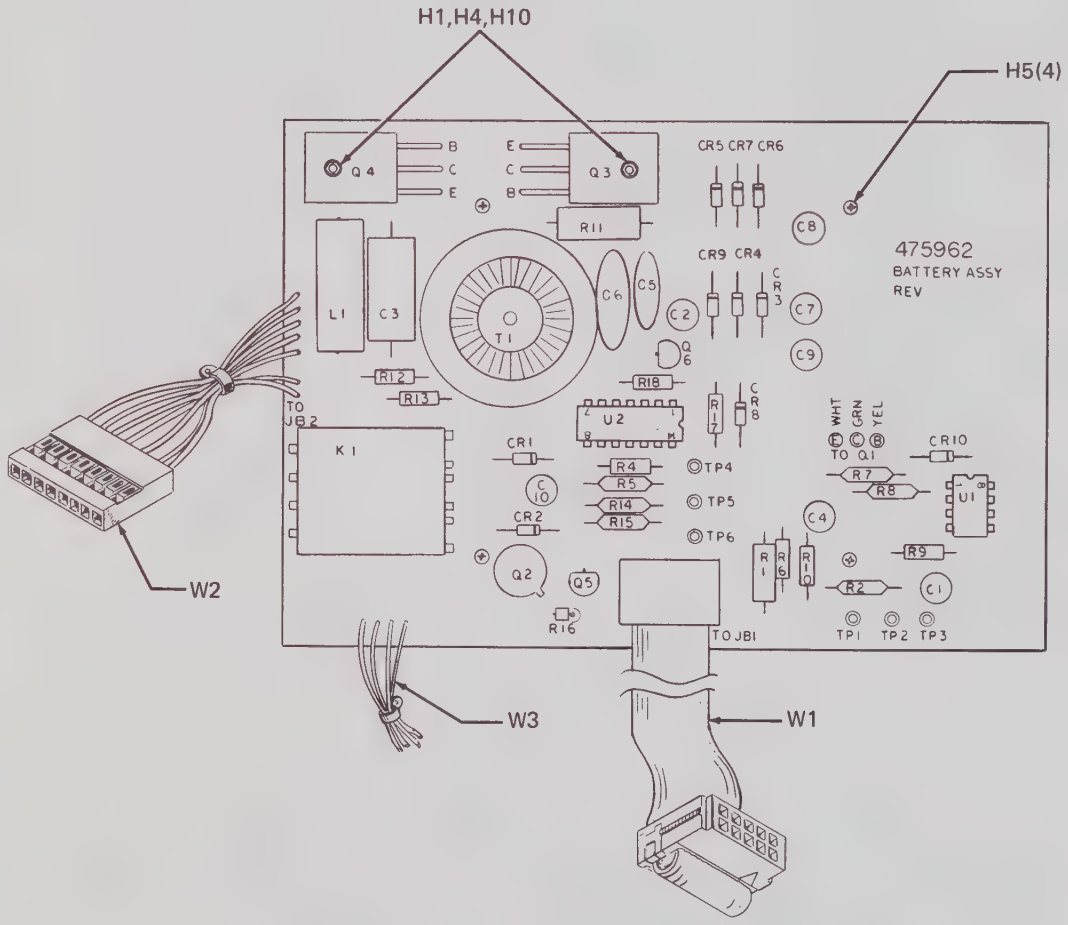


Figure 010-3. Battery Option -010 Assembly (cont)

Option-111
1 PPM TCXO

111-1. INTRODUCTION

111-2. Option -111 is a temperature compensated crystal oscillator (TCXO) with an intrinsic stability greater than the standard time base. This increased stability is due to a temperature compensation network. Figure 111-1 shows the frequency variation for change in temperature for an uncompensated oscillator and the compensation network effect. The resulting frequency deviation (solid line) is held to a minimum over the designated temperature range. If the temperature limits are exceeded, the time base stability may exceed the specified value.

111-3. SPECIFICATIONS

111-4. Specifications of the 7220A-111 Option are listed in Table 111-1. Comparative specifications for the other time bases available are listed in Section 1 of the 7220A Instruction Manual.

111-5. INSTALLATION

111-6. Installation of the 1 PPM TCXO (Option -111) necessitates removal of the counter's Main PCB; refer to disassembly instructions in Section 4 of the Instruction Manual. The TCXO is installed in the left rear corner of the Main PCB. Use the following procedure:

1. Unsolder and remove any other time base already installed.

2. Refer to Figure 111-2 and install the insulator and the TCXO.

3. While exercising care not to overheat the Main PCB, solder the TCXO connections.

4. Complete the following jumper and solder bridge arrangements as follows: If necessary, remove the short at SB2 (bottom of Main PCB, front left corner). Also, if necessary, remove the short at SB4 or SB5 (bottom of Main PCB, left rear corner). Solder a jumper at SB3 (left rear corner).

111-7. OPERATION

111-8. Operation of the instrument with the Option -111 installed is the same as operation of a standard instrument. Refer to Section 2 for operating instructions.

111-9. CALIBRATION

111-10. Calibration for the TCXO (Option -111) time base necessitates the use of a frequency reference with an accuracy of $\pm 1 \times 10^{-9}$. A cesium standard, such as the HP 5061A, is recommended. This calibration procedure calls for applying the reference frequency to Channel A and adjusting the time base for a counter display of the known input. At the 0.1 Hz Resolution setting on the counter, this method yields an adjustable accuracy of +5 parts in 10^8 (± one count error). Proceed with the following steps:

1. Remove the top cover from the 7220A.

2. Press the POWER switch to ON. Allow a minimum warmup of twenty minutes.

WARNING

LINE VOLTAGE IS PRESENT WHENEVER POWER CORD IS CONNECTED.

3. Apply an external frequency source of 10 MHz (100 mV rms) with an accuracy of $\pm 1 \times 10^{-9}$.

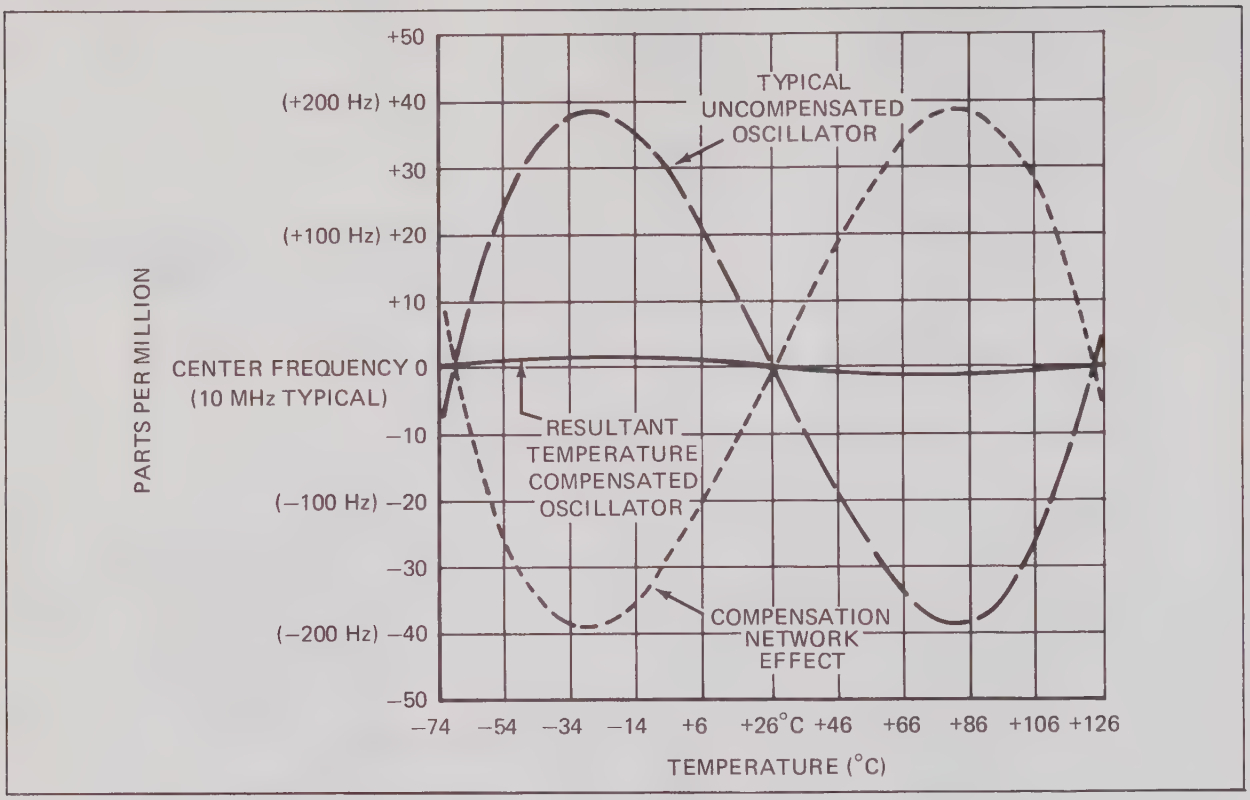


Figure 111-1. Compensation Effects

4. On the 7220A front panel, make the following settings:

RESOLUTION	1 Hz
CH A/CH B	125 MHz
ATTENUATION	as required for a stable display

5. Ascertain the offset frequency for the installed 1 PPM TCXO. This figure is stamped on the TCXO case (which is mounted on the left rear corner of the Main PCB).

Table 111-1. Option 7220A-111 Specifications

Nominal Frequency		10 MHz
Aging Rate	per day	—
	per month	$\pm 3 \times 10^{-7}$
	per year	$\pm 1 \times 10^{-6}$
Accuracy with Temperature* (0° to 40°C)		$\pm 1 \times 10^{-6}$
Line Voltage (10% line variation)		$\pm 2 \times 10^{-7}$
Battery Operation		$\pm 2 \times 10^{-7}$

**Includes errors caused by temperature variations during operation as well as all calibration errors when calibrated per specifications.*

6. Locate the OPT. -111 FREQ ADJ port on the lower right corner of 7220A rear panel.

7. Using a non-ferrous alignment tool (Fluke Part Number 542886, Fed. Stock 5120-724-3767), adjust the 1 PPM TCXO through the access port. Adjust for a displayed reading of 10.000000 MHz MINUS the offset frequency. For example, with an offset stamped on the TCXO of -3.7 Hz, adjust for a display of 10.000004 MHz.

8. Set the RESOLUTION control to 0.1 Hz.

9. Now adjust the TCXO for a displayed reading of 10.0000000 MHz MINUS the offset frequency For the example given in Step 7, the display should be 10.0000037 Hz.

10. Install the 7220A top cover.

111-11. REPLACEABLE PARTS

111-12. The 7220A Option -111 1 PPM Oscillator is a completely sealed unit containing no replacement parts. However, the 7220A-111 Option Kit (Fluke Part Number 575100) does include the -111 PPM Oscillator (Fluke Part Number 516104) and the Insulator (Fluke Part Number 487710), either of which may be ordered separately. For information about ordering, see Section 5.

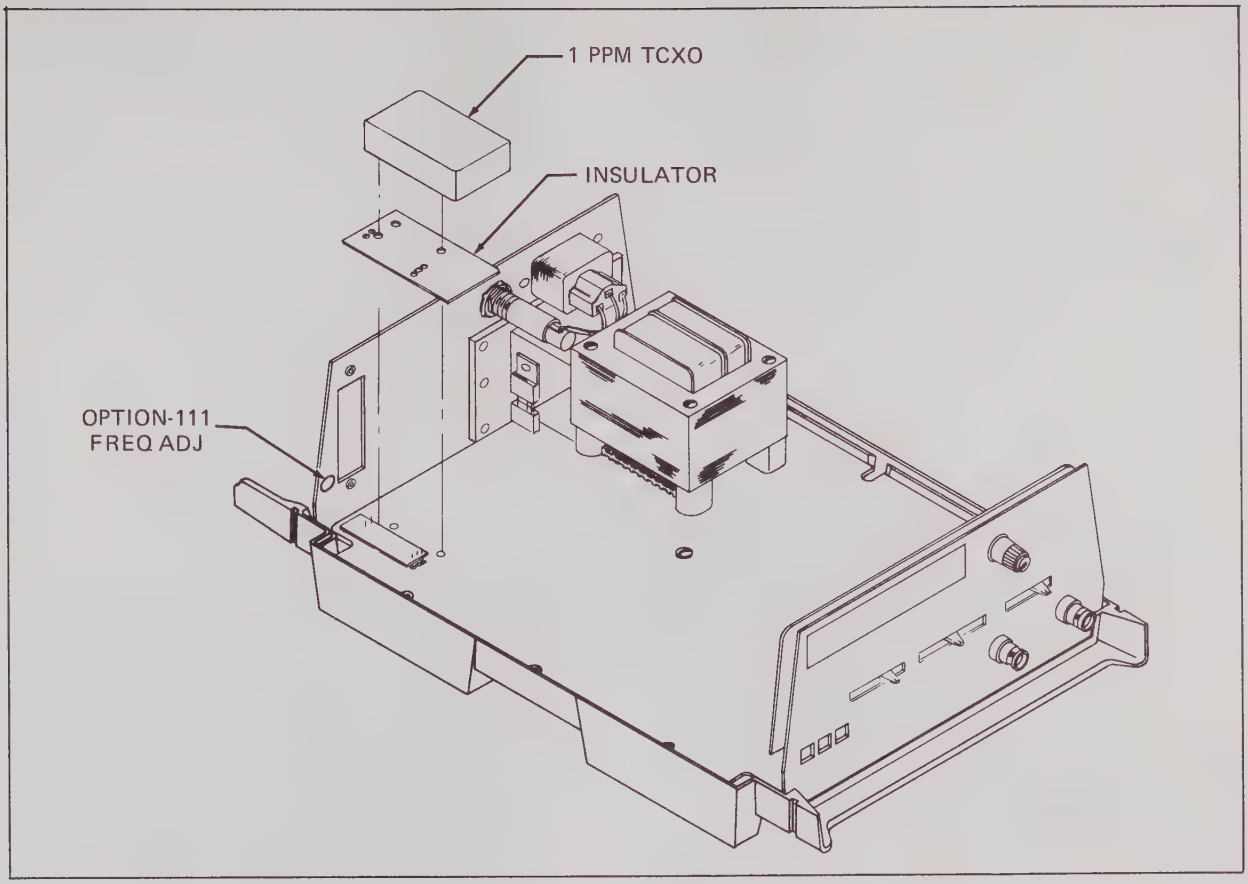


Figure 111-2. Installation

Option-131
Low Power Oven Time Base

131-1. INTRODUCTION

131-2. The -131 Option is a crystal oscillator inside a temperature stabilized oven. The oven uses an extremely small amount of power. After the assembly is warmed up, power consumption is 1 watt, typically. This allows oven controlled time base accuracy with a battery powered instrument. Operation and Calibration of an instrument equipped with the -131 Option is the same as with a standard instrument. Refer to Sections 2 and 4 of this manual for additional information.

131-3. SPECIFICATIONS

131-4. The specifications of the -131 Option are listed in Table 131-1.

131-5. INSTALLATION

6131-6. Installation of the Low Power Oven Time Base (Option -131) necessitates removal of the counter's Main PCB; refer to disassembly instructions included with Section 4. For each counter, the Low Power Oven Time Base is installed in the top left rear corner of the Main PCB. Use the following installation procedure:

1. Unsolder and remove any other time base already installed.

2. Referring to Figure 131-1, install the Low Power Oven Time Base and insulator. Use the provided hardware to secure the time base to the Main PCB.

3. While exercising care not to overheat the Main PCB, solder the time base connections.

4. Complete jumper and solder bridge arrangements on the Main PCB as described below:

a. 7220A: If necessary, remove the short at SB4 and jumper SB5 (bottom of Main PCB, left rear corner). Jumper SB2 (bottom, left front corner).

b. 7250A: If necessary, remove the short between W1 and +12V and jumper W1 to +5V (top of Main PCB, left front corner). Jumper SB2 (bottom of Main PCB, left front corner).

c. 7260A or 7261A: Remove the short at SB5 and jumper SB4 (bottom of Main PCB, left rear). Jumper SB2.

Table 131-1. -131 Option Specifications

Nominal Frequency	10 MHz
Aging Rate	1×10^{-7}/month*
Accuracy with Temperature (0° to 40°C)	$\pm 1 \times 10^{-7}$
Line Voltage (10% line variation)	2×10^{-8}
Warmup**	
10 minutes	5×10^{-7}
20 minutes	3×10^{-8}
Battery Operation	$\pm 5 \times 10^{-8}$

* After 5 days continuous operation.

** Specifies offset from final frequency value (the value after 24 hours).

131-7. CALIBRATION

131-8. Calibration for the Low Power Oven Time Base necessitates the use of a frequency reference with an accuracy of $\pm 1 \times 10^{-9}$. A cesium standard, such as the HP

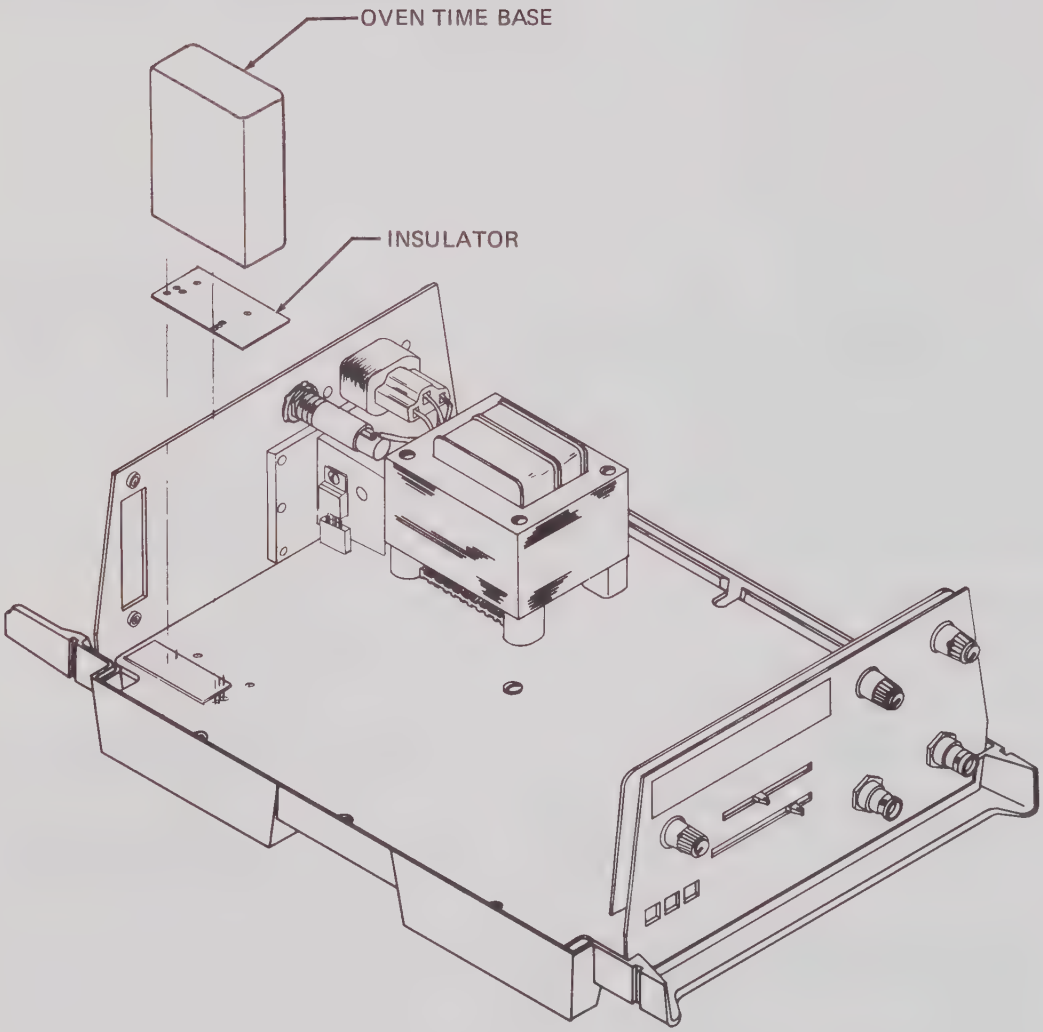


Figure 131-2. Installation

5061A, is recommended. This calibration procedure calls for applying the reference frequency to Channel A and adjusting the time base for a counter display of the known input. At the 0.1 Hz RESOLUTION setting on the counter, this method yields an adjustable accuracy of 2 parts in 10^8 (± one count error). Proceed with the following steps:

1. Ensure that the counter's top and bottom covers are installed.

2. Apply power to the counter and allow for a minumum warmup of 20 minutes. When possible a warmup of 24 hours is preferred.

3. Set counter controls and connections as defined in Section 4 of this manual ("Time Base Calibration").

4. Connect the 5 MHz (100 mV) frequency reference output to CHANNEL A input on the counter.

5. If necessary, adjust the time base so that the counter's display corresponds to the first reading presented in Table 6131-2. The adjustment is accessed through a hole in the left rear corner of the bottom case half. Use a JFD 5284 (or equivalent) non-ferrous adjustment tool. If installed at the rear of the bottom case half, the bail will have to be removed to allow access.

6. Change the counter's RESOLUTION setting to the next step listed in Table 6131-2 and repeat step (5) for the respective display. Display update in the 0.1 Hz setting occurs every ten seconds.

NOTE

When the OVFL LED is illuminated, observe the GATE LED (on) to verify that a measurement is being made.

6131-9. LIST OF REPLACEABLE PARTS

131-10. A replacement oscillator can be ordered by using Fluke Part Number 516112. The Manufacturer's Federal Supply Code is 89536 and the Manufacturer's Part Number is 516112. The insulator can be ordered with part number 487710. Refer to Section 5 for ordering information.

Table 131-2. Calibration

RESOLUTION	DISPLAY (±1 COUNT)
1 Hz	5000.000 kHz (7250A, 7260A, 7261A) 5.000000 MHz (7220A)
0.1 Hz	000.0000 kHz* (7250A) 5000.0000 kHz (7260A, 7261A) 5.0000000 MHz (7220A)

Option -132
Superior Low Power Oven Time Base

132-1. INTRODUCTION

132-2. The -132 Option is a crystal oscillator inside a temperature stabilized oven. The oven uses an extremely small amount of power. After the assembly is warmed up, power consumption is 1 watt, typically. This allows oven controlled time base accuracy with a battery powered instrument. Operation and Calibration of an instrument equipped with the -132 Option is the same as with a standard instrument. Refer to Sections 2 and 4 of this manual for additional information.

132-3. SPECIFICATIONS

132-4. The specifications of the -132 Option are listed in Table 132-1.

132-5. INSTALLATION

132-6. Installation of the Superior Low Power Oven Time Base (Option -132) necessitates removal of the counter's Main PCB; refer to disassembly instructions included with Section 4. For each counter, the Superior Low Power Oven Time Base is installed in the top left rear corner of the Main PCB. Use the following installation procedure:

1. Unsolder and remove any other time base already installed.

2. Referring to figure 132-1, install the Superior Low Power Oven Time Base and insulator. Use the provided hardware to secure the time base to the Main PCB.

3. While exercising care not to overheat the Main PCB, solder the time base connections.

4. Complete jumper and solder bridge arrangements on the Main PCB as described below:

a. 7220A: If necessary, remove the short at SB4 and jumper SB5 (bottom of Main PCB, left rear corner). Jumper SB2 (bottom, left front corner).

b. 7250A: If necessary, remove the short between W1 and +12V and jumper W1 to +5V (top of Main PCB, left front corner). Jumper SB2 (bottom of Main PCB, left front corner).

c. 7260A or 7261A: Remove the short at SB5 and jumper SB4 (bottom of Main PCB, left rear). Jumper SB2.

Table 132-1. -132 Option Specifications

Nominal Frequency	10 MHz
Aging Rate	$\pm 3 \times 10^{-9}$/day*
	$\pm 5 \times 10^{-8}$/month*
Accuracy with Temperature (0° to 40°C)	$\pm 3 \times 10^{-8}$
Line Voltage (10% line variation)	$\pm 4 \times 10^{-9}$
Warmup	
10 minutes	$\pm 5 \times 10^{-7}$
20 minutes	$\pm 3 \times 10^{-8}$
Battery Operation	$\pm 1 \times 10^{-8}$

* After 5 days continuous operation.

** Specifies offset from final frequency value (the value after 24 hours).

132-7. CALIBRATION

132-8. Calibration for the Superior Low Power Oven Time Base necessitates the use of a frequency reference

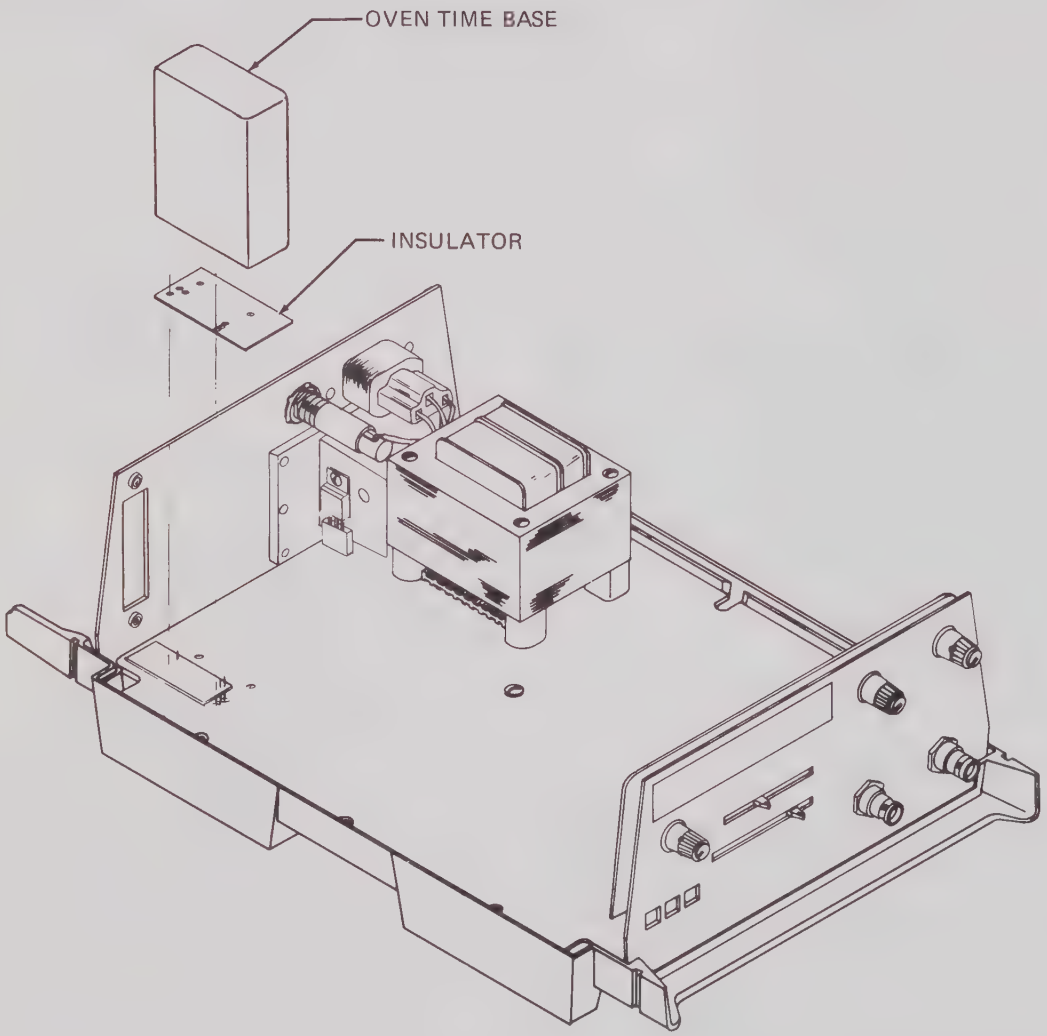


Figure 132-1. Installation

with an accuracy of ±1 X 10^9. A cesium standard, such as the HP 5061A, is recommended. This calibration procedure calls for applying the reference frequency to Channel A and adjusting the time base for a counter display of the known input. At the 0.1 Hz RESOLUTION setting on the counter, this method yields an adjustable accuracy of 2 parts in 10^8 (±1 count error). Proceed with the following steps:

1. Ensure that the counter's top and bottom covers are installed.

2. Apply power to the counter and allow for a minumum warmup of 20 minutes. When possible a warmup of 24 hours is preferred.

3. Set counter controls and connections as defined in Section 4 of this manual ("Time Base Calibration").

4. Connect the 5 MHz (100 mV) frequency reference output to CHANNEL A input on the counter.

5. If necessary, adjust the time base so that the counter's display corresponds to the first reading presented in Table 132-2. The adjustment is accessed through a hole in the left rear corner of the bottom case half. Use a JFD 5284 (or equivalent) nonferrous adjustment tool. If installed at the rear of the bottom case half, the bail will have to be removed to allow access.

6. Change the counter's RESOLUTION setting to the next step listed in Table 132-2 and repeat step (5) for the respective display. Display update in the 0.1 Hz setting occurs every ten seconds.

NOTE

When the OVFL LED is illuminated, observe the GATE LED (on) to verify that a measurement is being made.

132-9. LIST OF REPLACEABLE PARTS

132-10. A replacement oscillator can be ordered by using the Fluke Part Number 516096. The Manufacturer's Federal Supply Code is 89536 and the Manufacturer's Part Number is 516096. The insulator can be ordered with Fluke Part Number 487710. Ordering information is given in Section 5 of the Instruction Manual.

Table 6132-2. Calibration

RESOLUTION	DISPLAY (±1 COUNT)
1 Hz	5000.000 kHz (7250A, 7260A, 7261A) 5.000000 MHz (7220A)
0.1 Hz	000.0000 kHz* (7250A) 5000.0000 kHz (7260A, 7261A) 5.0000000 MHz (7220A)

Option -351
Resolution Multiplier

351-1. INTRODUCTION

351-2. The Resolution Multiplier Option -351 is used to provide high resolution for low frequency Channel A input signals. This is accomplished by using a phase-locked loop to multiply the conditioned signals by a factor of 1000 before they are counted. This has the effect of increasing the four available Resolution settings by the same factor of 1000. When installed, the Resolution Multiplier may be selected by the 7220A front panel Function slide switch. The Resolution settings available in the Resolution Multiplier mode are color coded by the blue band on the front panel. When the Resolution Multiplier mode is not selected by the CH A/CH B slide switch, power is removed from the circuit.

351-3. SPECIFICATIONS

351-4. The specifications for the Resolution Multiplier Option -351 are given in Table 351-1.

351-5. INSTALLATION

351-6. Use the following procedure to install the Option -351:

1. Release the POWER switch to STBY and remove the line power cord. Remove the top cover. Remember that the case bottom is secured to the Main PCB Assembly with one central screw. Prying the case top up while pressing down on the case bottom may damage the Main PCB.

2. Referring to Figure 351-1, orient the Option -351 PCB so the components are facing the front, and gently guide the PCB down over the two alignment rods mounted on the Main PCB so that the eight connector pins on the Main PCB are properly inserted into the eight connectors on the Option -351 PCB. Firmly push the Option -351 PCB until it is securely connected to the Main PCB.

3. Reconnect the top case half, making sure that the Front and Rear panels fit into their appropriate grooves in the case top half. Slide the top half into place uniformly. Firmly squeeze top and bottom together (at front and rear), and reinstall the six securing screws.

NOTE

Proper RFI shielding depends on top and bottom case halves being securely mated.

Table 351-1. Specifications

7220A Input: Channel A					
Operating Range: 10 Hz to 10 kHz					
7220A Resolution with Option -351:	(Hz)	0.1	0.01	0.001	0.0001
Gate Time:	(sec)	0.01	0.1	1	10
Accuracy: ±2 counts ± timebase accuracy with signal input = 100mV RMS.					

351-7. OPERATION

351-8. The Resolution Multiplier may only be used with Channel A signal inputs, and its operating range is 10 Hz to 10 kHz. As can be seen in the Specification Table, the Resolution Multiplier can be used to increase the measurement resolution for the same gate times as without the Resolution Multiplier. For example, without Option -351 the gate time for the 0.1 Hz resolution is 10 seconds, whereas with the Option -351, the same 10 second gate time allows 0.0001 Hz resolution.

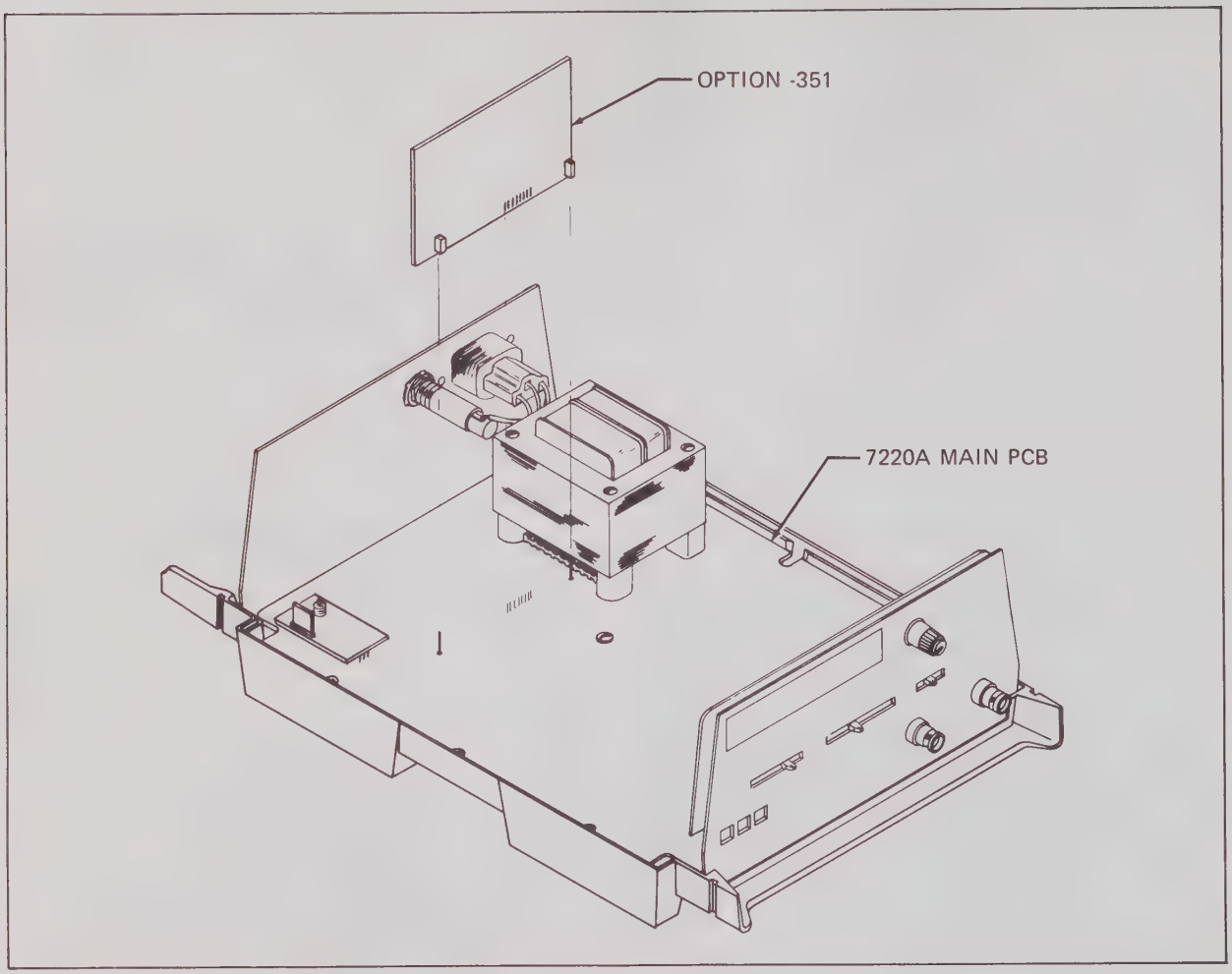


Figure 351-1. Option -351 Installation

351-9. The Resolution Multiplier can also be used to speed up measurement cycles by selecting shorter gate times. For example, a low frequency signal being measured with a resolution of 0.1 Hz requires a gate time of ten seconds. To adjust the frequency of the signal being measured while observing the counter would be very difficult because of the time lag between the adjustment and the resultant display on the counter. This problem can be solved with the Resolution Multiplier by selecting the 0.1 Hz or 0.01 Hz resolution settings, which have fast gate times of only 0.01 second or 0.1 second, thus decreasing the time lag to an acceptable amount.

351-10. To operate the counter with the Resolution Multiplier, proceed as follows:

1. Connect a 10 Hz to 10 kHz input signal to the Channel A front panel BNC connector.

2. Set the front panel CH A/CH B switch to RES MULT.

3. Select the desired resolution. The LED Gate annunciator at far left of the display will flash at the beginning of each gate time. The unit of measurement for the frequency on the display will be Hz.

351-11. THEORY OF OPERATION

351-12. The operation of the Resolution Multiplier is illustrated in Figure 351-2. The heart of the circuit is the frequency phase comparator U2 and the voltage controlled oscillator (VCO) Q6. The frequency phase comparator provides a feedback loop to maintain the precise dc voltage level needed for the VCO to oscillate at a frequency 1000 times the signal input.

351-13. As can be seen in Figure 351-2, the input signal from the Channel A preamp enters one input of the phase comparator. The second input to the comparator receives the actual output of the multiplier circuit after being divided by a factor of 1000. When the output of the

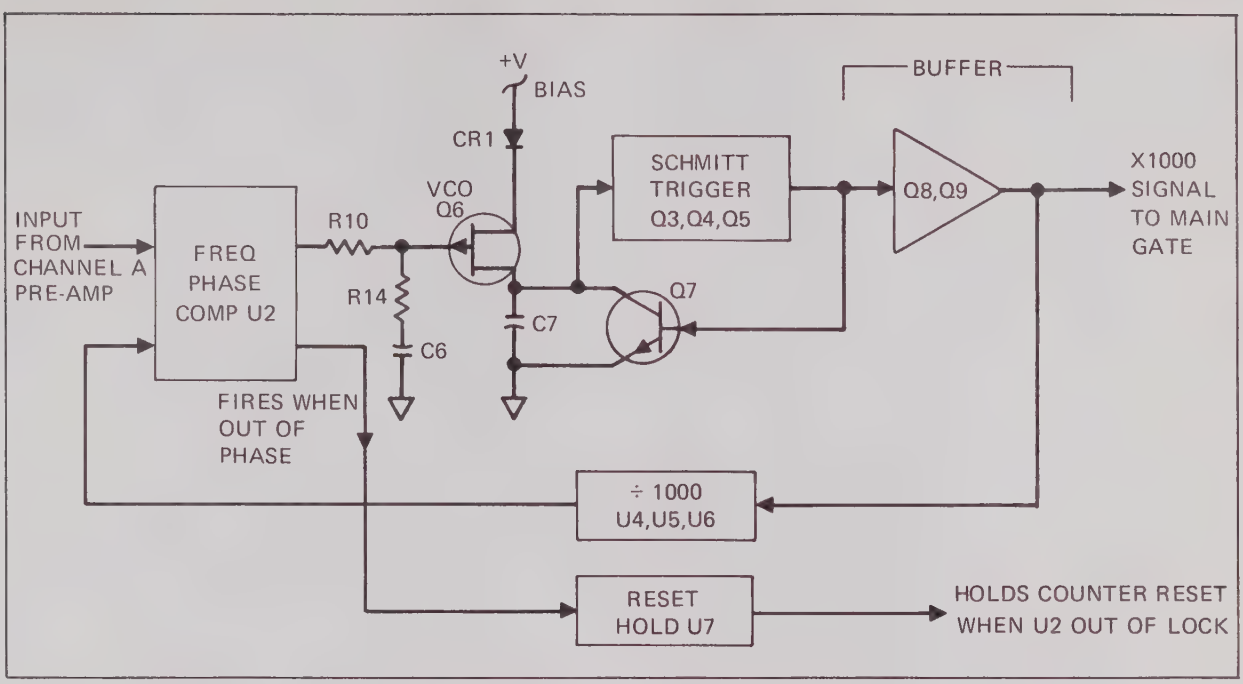


Figure 351-2. Resolution Multiplier Circuit

multiplier is exactly 1000 times greater than the input from the preamp, the two comparator inputs are in phase and a constant dc level is present at the VCO input. The comparator output, filtered by R10, R14, and C6, drives Q6 and controls the charging rate of C7 through CR1. The voltage across C7 is applied to the input of a Schmitt trigger (which changes state at some threshold point). The Schmitt trigger causes Q7 to discharge C7 to begin the action again.

351-14. The output of the Schmitt trigger is buffered by Q8 and Q9 (NPN type) and fed to the Main Gate for counting. The output is also divided by 1000 and fed back for comparison with the input from the Channel A preamp to form the phase-locked loop. Any frequency or phase difference between the two inputs will cause the output dc level applied to the VCO to change to maintain multiplied output equal to 1000 times the input. Whenever the multiplier is not locked in phase, it triggers the timer U7, which generates the reset pulse that resets the counters. This holds off the counter during start-up or when an invalid input is present at the multiplier.

351-15. PERFORMANCE CHECK

351-16. The following procedure can be used to check whether the installed Resolution Multiplier Option -351 is functioning properly. It is assumed when following this procedure that the 7220A is functioning properly and within the instrument specifications listed in Section 1 of the Instruction Manual. If the 7220A Option -351 fails to satisfy the requirements of this performance check, refer to Section 4 of the Instruction Manual and verify that the 7220A satisfies the requirements for the instrument performance test (Channel B does not need to be tested, since it is not used in the Resolution Multiplier mode).

351-17. A low frequency signal source is needed for this procedure. The Fluke 6011A is recommended.

1. Set the 7220A CH A/CH B slide switch to RES MULT. Be sure the rear panel REF switch is set to INT.

2. Connect the low frequency signal source to the 7220A Channel A input. Set the input frequency to 100 Hz at 20 mV rms.

3. Set the 7220A RESOLUTION to .0001 Hz and confirm that the resultant display is as listed in Table 351-2.

4. Repeat Step 3 for the next three RESOLUTION settings in Table 351-2.

5. Set the RESOLUTION to .001 Hz and set the input signal to 10 Hz at 20 mV rms. Confirm that the display is as listed in Table 351-2. Repeat this for the next three input signals listed.

6. Set the input signal to 25 kHz at 20 mV rms and confirm the display is as listed. The GATE LED

Table 351-2. Option -351 Display

RESOLUTION	INPUT SIGNAL	CORRECT DISPLAY (±2 counts ± timebase accuracy)
.0001 Hz	100 Hz (20 mV rms)	100.0000 Hz
.001 Hz	100 Hz "	100.000 Hz
.01 Hz	100 Hz "	100.00 Hz
.1 Hz	100 Hz "	100.0 Hz
.001 Hz	10 Hz "	10.000 Hz
	100 Hz "	100.000 Hz
	1 kHz "	1000.000 Hz
	10 kHz "	10000.000 Hz
.001 Hz	25 kHz "	0.000 Hz
.001 Hz	1 Hz "	0.000 Hz

should not be illuminated. This checks the out-of-lock feature.

7. Repeat Step 6 for 1 Hz.

8. Set the input signal to 10 Hz. When the display is stable, step the input signal up to 10 kHz. Confirm that the second reading after changing the input signal is correct.

351-18. TROUBLESHOOTING

351-19. If the Resolution Multiplier fails the Performance Check, repair may be necessary. The following steps provide guidelines for troubleshooting.

1. Remove the 7220A top cover.

2. Set the front panel CH A/CH B switch to RES MULT.

3. Apply an appropriate signal between 10 Hz and 10 kHz to the Channel A input.

4. Check the following points using an oscilloscope:

Check:	You should see:
U2-16	+12V
U3-2	Pulses 1000X frequency of input, TTL
U6-12	Pulses 1/10 frequency of U3-2
U5-11	Pulses 1/10 frequency of U6-12
U4-11	Pulses 1/10 frequency of U5-11.

5. Check for pulses at U3-10. The presence of pulses indicates that the phase-locked loop is not locked. Check U2 and the VCO circuit involving Q3 through Q9.

351-20. LIST OF REPLACEABLE PARTS

351-21. A list of replaceable parts for the Resolution Multiplier are provided in Table 351-3. The component locations can be found in Figure 351-3.

Table 351-3. Resolution Multiplier (Option -351)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	⊗ RESOLUTION MULTIPLIER, OPTION-351 FIGURE 6351-3 (7220A-4006T)	ORDER	BY	OPTION -351	1		
C1	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	2		
C2	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	6		
C3	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C4	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C5	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C6	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
C7	CAP, MICA, 22 PF +/-5%, 500V	148551	72136	DM15E220J	1		
C8	CAP, CER, 0.01 UF +/-20%, 100V	149153	56289	C023B101F103M	REF		
C9	CAP, TA, 10 UF +/-20%, 20V	330662	56289	196D106X0020KA1	REF		
CR1	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	2	1	
CR2	DIODE, SI, HI-SPEED SWITCHING	203323	07910	1N4448	REF		
J6	CONNECTOR, AMP SOCKET	375329	00779	85863-3	8		
MP1	CONNECTOR, PCB MOUNT TEST JACK	149112	74970	105-0753	2		
Q1	XSTR, SI, PNP	352369	12040	2N4403	1	1	
Q2	XSTR, SI, NPN	218396	04713	MPS6520	2	1	
Q3	XSTR, PNP, HI-SPEED SWITCHING	369629	07263	S43576	2	1	
Q4	XSTR, PNP, HI-SPEED SWITCHING	369629	07263	S43576	REF		
Q5	XSTR, FET, DUAL N-CHANNEL	379271	17856	E421	1	1	
Q6	XSTR, FET, P-CHANNEL, JUNCTION, TO-92	403600	04713	2N4342	1	1	
Q7	XSTR, NPN, SI, HI-SPEED SATURATED SWITCH	369645	07263	2N4274	3	1	
Q8	XSTR, NPN, SI, HI-SPEED SATURATED SWITCH	369645	07263	2N4274	REF		
Q9	XSTR, NPN, SI, HI-SPEED SATURATED SWITCH	369645	07263	2N4274	REF		
Q10	XSTR, SI, NPN	218396	04713	MPS6520	REF		
R1	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	3		
R2	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	6		
R3	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	REF		
R4	RES, DEP. CAR, 22K +/-5%, 1/4W	348870	80031	CR251-4-5P22K	2		
R5	RES, DEP. CAR, 560 +/-5%, 1/4W	385948	80031	CR251-4-5P560E	1		
R6	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R7	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R8	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	2		
R9	RES, DEP. CAR, 4.7K +/-5%, 1/4W	348821	80031	CR251-4-5P4K7	REF		
R10	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR215-4-5P100K	2		
R11	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R12	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R13	RES, DEP. CAR, 1K +/-5%, 1/4W	343426	80031	CR251-4-5P1K	REF		
R14	RES, DEP. CAR, 3.3K +/-5%, 1/4W	348813	80031	CR251-4-5P3K3	1		
R15	RES, DEP. CAR, 1.2K +/-5%, 1/4W	441378	80031	CR251-4-5P1K2	1		
R16	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	2		
R17	RES, DEP. CAR, 1M +/-5%, 1/4W	348987	80031	CR251-4-5P1M	1		
R18	RES, DEP. CAR, 470K +/-5%, 1/4W	342634	80031	CR251-4-5P470K	1		
R19	RES, DEP. CAR, 150 +/-5%, 1/4W	343442	80031	CR251-4-5P150E	1		
R20	RES, DEP. CAR, 22K +/-5%, 1/4W	348870	80031	CR251-4-5P22K	REF		
R21	RES, DEP. CAR, 820 +/-5%, 1/4W	442327	80031	CR251-4-5P820E	1		
R22	RES, DEP. CAR, 390 +/-5%, 1/4W	441543	80031	CR251-4-5P390E	REF		
R23	RES, DEP. CAR, 180 +/-5%, 1/4W	441436	80031	CR251-4-5P180E	1		
R24	RES, DEP. CAR, 2.7K +/-5%, 1/4W	386490	80031	CR251-4-5P2K7	REF		

Table 351-3. Resolution Multiplier (Option -351) (cont)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
R25	RES, DEP. CAR, 100K +/-5%, 1/4W	348920	80031	CR215-4-5P100K	REF		
R26	RES, DEP. CAR, 10K +/-5%, 1/4W	348839	80031	CR251-4-5P10K	1		
U2⊘	IC, LIN, C-MOS, PHASE LOCKED LOOP	403584	02735	CD4046AE	1	1	
U3	IC, TTL, HEX INVERTER	288605	01295	SN7416N	1	1	
U4	IC, TTL, DECADE COUNTER	402545	01295	SN74LS90N	2	1	
U5	IC, TTL, DECADE COUNTER	402545	01295	SN74LS90N	REF		
U6	IC, TTL, 30-MHz PRESETTABLE DECADE	393256	01295	SN74LS196N	1	1	
U7	IC, LINEAR TIMER	402610	18324	NE555N	1	1	

NOTE: ⊘ Indicates the item can be damaged by static discharge.

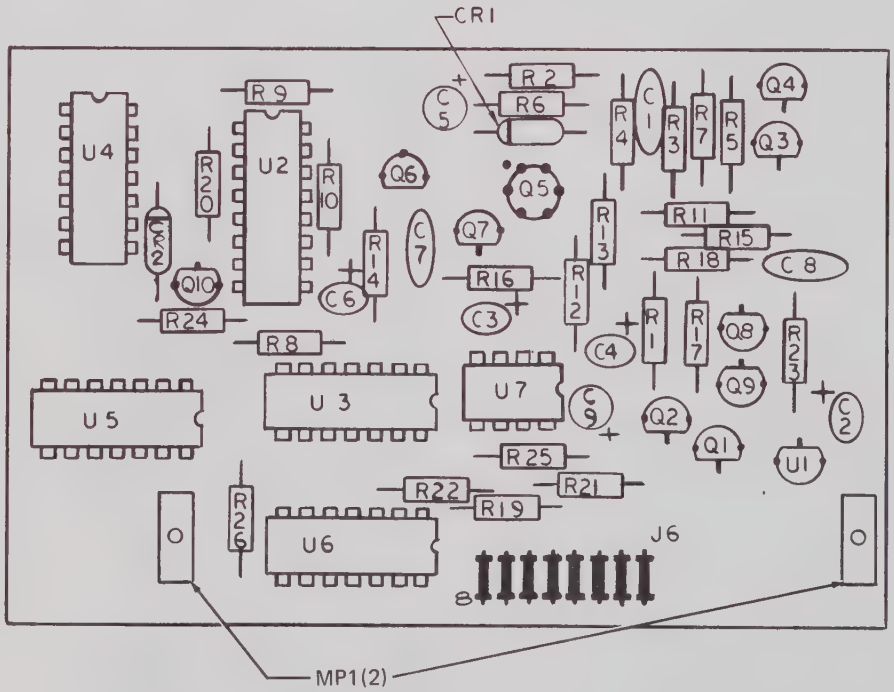


Figure 351-3. Resolution Multiplier (Option -351)

Option -521
Printer Interface

521-1. INTRODUCTION

521-2. The purpose of the Printer Interface is to allow a Fluke counter (7220A, 7250A, 7260A, or 7261A) to be connected to a Fluke printer (2020A, 2021A, or 2030A) for printed output of counter measurements. The Printer Interface consists of the 72XXA-521 Digital Interface PCB, which is factory-installed in the counter.

NOTE

The 72XXA-521 Digital Interface PCB is also used in the IEEE Interface system for the counters. For information about its function in the IEEE Interface, refer to the 72XXA-521/-522 IEEE Interface.

521-3. The 2020A or 2021A printers must have Printer Optioin -004 installed. The 2030A is ready for connection without any additional options. The counter and printer are connected by an accessory cable. The cable is available in either a 2 foot (Y7203), or 5 foot (Y7204) length.

521-4. Data is transferred from the counter to the printer in a bit-parallel, character-serial manner. The printout from the printer includes the measurement reading of the counter and the measurement unit.

521-5. OPERATING INSTRUCTIONS

521-6. Preparation

521-7. To prepare the instruments for printing measurements, follow these steps:

1. Connect the counter and printer together via cable Y7203 or Y7204. Cable connections are made at the rear panel of each instrument.

2. Apply power to each instrument.

3. Apply a valid input signal to the counter, and set the controls as desired.

4. Set the printer controls as desired. If necessary, refer to the printer manual for operating instructions.

521-8. Printing Measurements

521-9. Figure 521-1 shows three examples of measurement printouts made by a 2030A printer. Notice in all 3 examples that all counter digits are printed (either 8 or 9, depending on the counter) including any leading zeros. Notice also in the first example that 8 digits are printed for the 7250A. The 7250A has a 7 digit display, but it supplies 8 digits of valid information to the printer.

521-10. The numbers 2 and 3 in the column at the far left are non-selectable instrument addresses which have been preassigned at the factory in conformance with a printer addressing feature. All the counters have been assigned address 2 except the 7220A, which has been assigned address 3. The 7220A has a unique address because its measurement capacity is one digit greater than the other counters.

521-11. The addresses correspond to a jumper pin on the Digital Interface PCB in the counter. If the printer does not print measurement data correctly, or if it does not print at all, the jumper may be in the wrong position. To check the position or move the jumper, refer to the following paragraph.

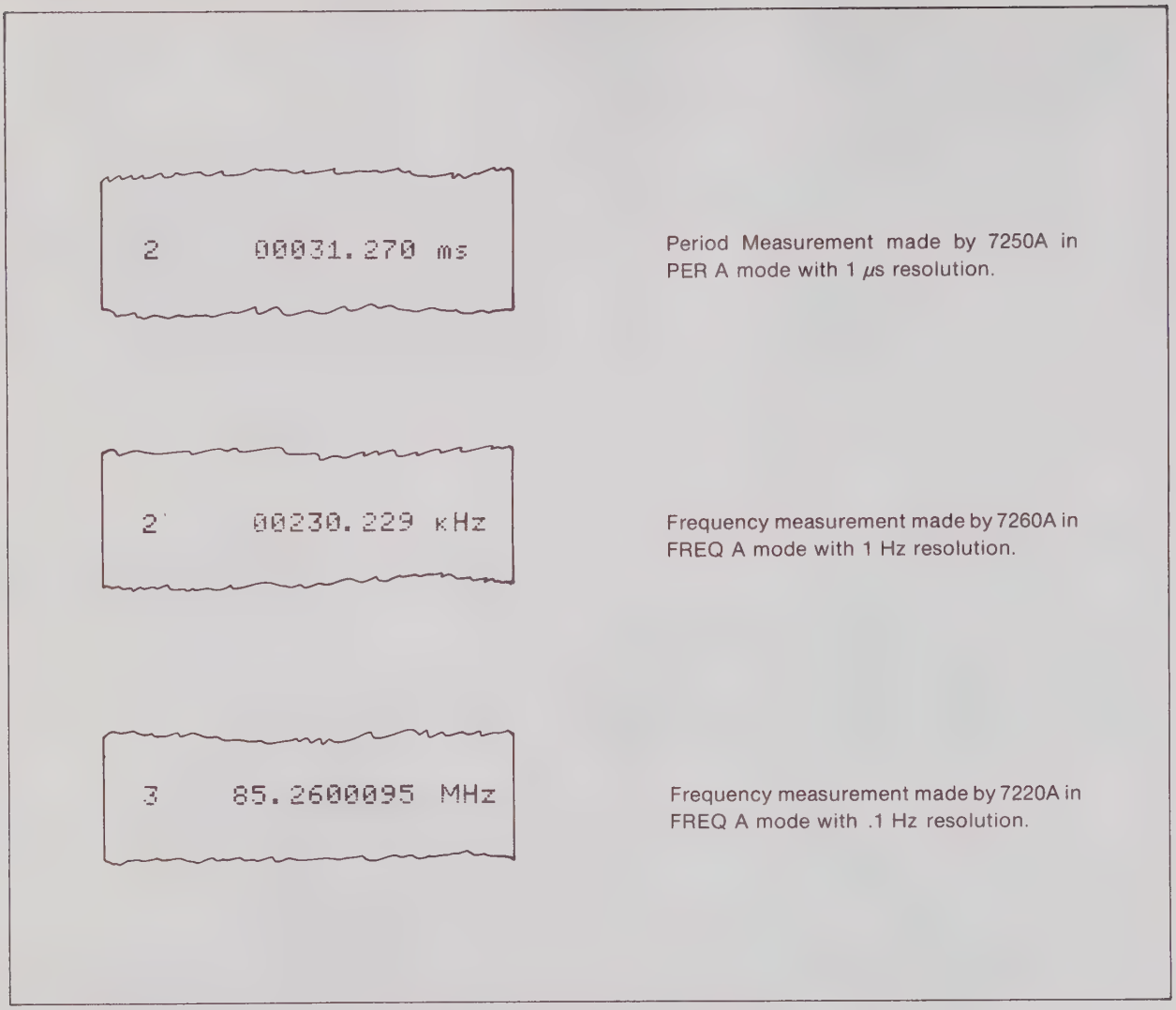

2 00031.270 ms
Period Measurement made by 7250A in PER A mode with 1 μs resolution.
2 00230.229 kHz
Frequency measurement made by 7260A in FREQ A mode with 1 Hz resolution.
3 85.2600095 MHz
Frequency measurement made by 7220A in FREQ A mode with .1 Hz resolution.

Figure 521-1. Printer Output Examples.

521-12. Moving the Address Jumper

WARNING

THESE SERVICING INSTRUCTIONS ARE FOR USE BY QUALIFIED PERSONNEL ONLY. TO AVOID ELECTRIC SHOCK, DO NOT PERFORM ANY SERVICING UNLESS YOU ARE QUALIFIED TO DO SO.

521-13. To examine the address jumper, disconnect the counter power cord and remove the top cover of the counter. Be careful not to separate the front and rear panels from the bottom case half. Locate the jumper on the upper left corner of the component side of the Digital Interface PCB. Refer to the table in Figure 521-2, and examine the jumper to determine the address selected. If the proper address is not selected, remove the jumper pin by pulling it straight out. Refer to the table in Figure 521-2 and determine the proper wiper and slot location (the jumper slot numbers are also printed on the back of the PCB). Firmly insert the jumper into place.

521-14. Operating Notes

521-15. In the single print mode, the printer prints the first counter reading it receives and then stops. In the continuous print mode, the printer prints out counter readings as it receives them, up to a maximum rate of 3 readings per second. When the measurement cycle rate of the counter is greater than 3 per second (such as frequency measurements made with 100 Hz resolution), then not all counter readings will be printed out. The printer also will not print out readings made in the Totalize mode by the 7250A, 7260A, or 7261A.

ADDRESS JUMPER

JUMPER POSITION	CONNECTIONS	
	WIPER	SLOT
Do not use 0	W1C	0
Do not use 1	W1A	1
7250A, 7260A, 7261A 2	W1C	2
7220A 3	W1A	3
Do not use 4	W1C	4
Do not use 5	W1B	5
Do not use 6	W1B	6
Do not use 7	W1B	7
Do not use 8	W1A	8
Do not use 9	W1C	9

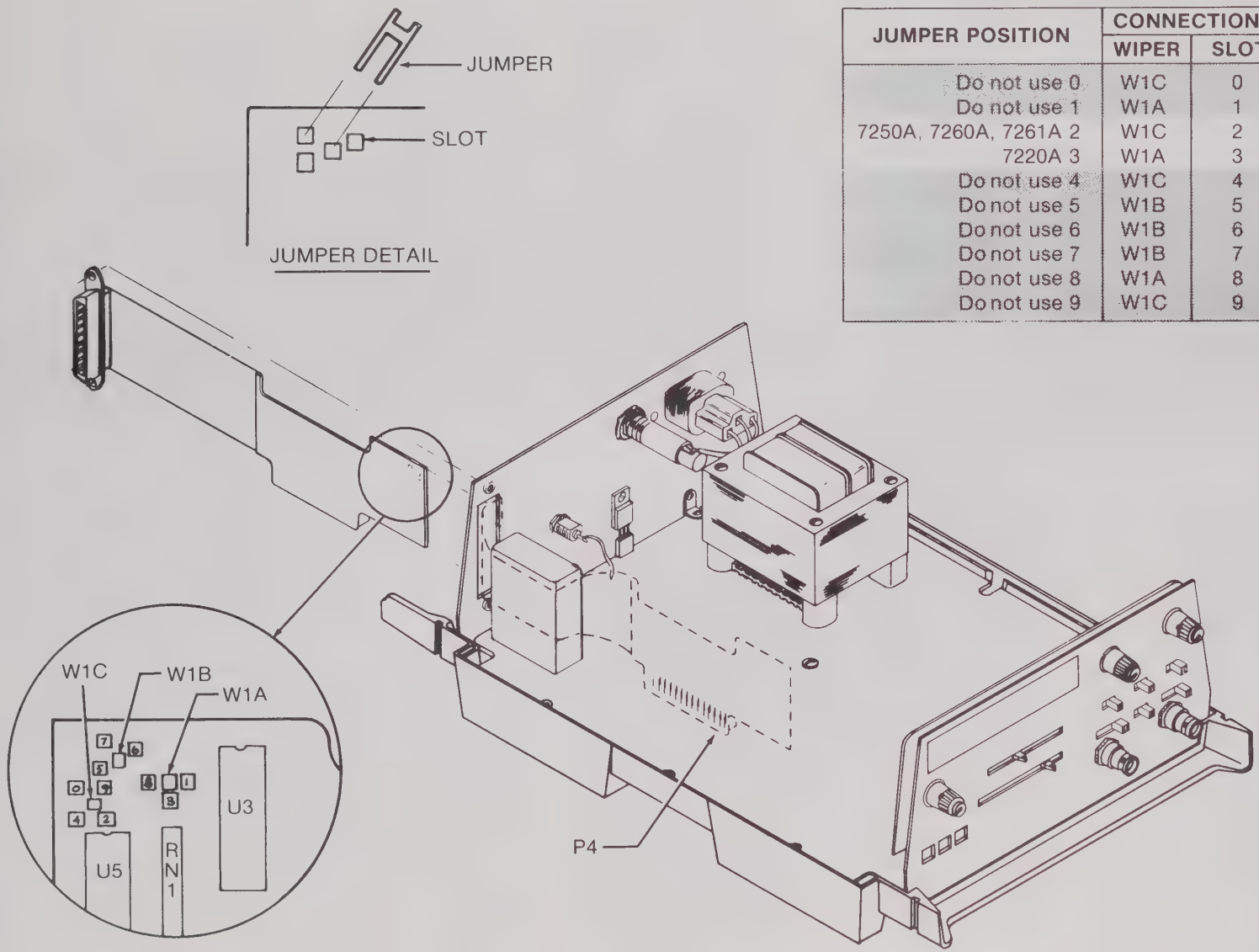


Figure 521-2 Address Jumper

521-16. It is important to note that the printer gives no indication when an overflow condition exists in the counter. The printer will print whatever digits are present on the display at the end of the reading, whether the counter display has overflowed or not. The one exception to this is the 7250A, which supplies eight digits of valid information to the printer before overflowing, even though it has a seven digit display.

521-17. THEORY OF OPERATION

521-18. Overview

521-19. An overview of the operation of the Printer Interface is presented at the top of Figure 521-3. As shown in the figure, the printer functions primarily as a passive listener which receives and prints counter readings without affecting the operation of the counter. The printer does have a limited talk function, however. It must first send an address to the Printer Interface and have the address acknowledged by the Interface before data can be transferred from the counter.

521-20. An expanded view of the interface operation is shown in the large box at the bottom of Figure 521-3. Data transfer is controlled by the control logic, which receives address input from the printer, and three inputs from the counter, OSC, DS1, and BUSY. OSC is the oscillator signal from the scan oscillator that controls the timing of the internal strobing and mutiplexing of the counter. DS1 is the first Digit Strobe (LSD) of the counter, and BUSY is a signal from the control logic of the counter which indicates that a measurement cycle is in progress.

521-21. The Interface Control Logic has three outputs. One output enables the Data Buffer, and the other two are the control lines $\overline{\text{DATVAL}}$ and $\overline{\text{ADRVAL}}$ that are sent to the printer to enable data transfer.

521-22. Detailed Description

521-23. The following paragraphs discuss the sequence of events that take place before, during, and after data transfer. Refer to the block diagram at the bottom of Figure 521-3. The timing can be seen at the top of Figures 521-4 and 521-5, and the circuits are shown in detail in the schematic in Section 8 of the counter Instruction Manual.

521-24. ADDRESS DECODING

521-25. Data Transfer is initiated by the printer. The printer places a 4 bit BCD address on lines A0, A1, A2 and A3. The BCD address is converted to decimal, and if the address corresponds to the address selected by the address jumper, a high signal passes on to the Control Logic. This signal then enables the Data Buffer, and is also inverted and returned to the printer as a low $\overline{\text{ADRVAL}}$.

521-26. DATA TRANSFER

521-27 The low $\overline{\text{ADRVAL}}$ is sent to the microcomputer of the printer and indicates that the Printer Interface has received the address and the counter is preparing to transfer data. After the counter takes a reading, BUSY goes low, then high, which tells the Interface Control Logic a reading has been completed. The next DS1 digit strobe enables the $\overline{\text{DATVAL}}$ line, which is the inverted OSC signal. The digits of the information are now transferred in the sequence indicated in Figures 521-4 and 521-5. The 7220A is shown in a separate figure because it is a nine-digit counter, and nine digits of information are passed instead of eight.

521-28. The timing of the data transfer is controlled by the $\overline{\text{DATVAL}}$ pulses. One $\overline{\text{DATVAL}}$ pulse occurs for each digit of information transferred. All the counters have eight $\overline{\text{DATVAL}}$ pulses except the 7220A, which has nine for its nine digits. The second DS1 digit strobe disables the $\overline{\text{DATVAL}}$ pulses, thus ending the data transfer.

521-29. Data Format

521-30. The format for the data transfer is shown in Figures 521-4 and 521-5. The digits are transferred in the sequence shown, beginning with the LSD, then the MSD, and continuing in descending order of significance. Note that the 7250A provides eight digits of information to the printer even though the 7250A has a seven digit display. The MSD in Figure 521-5 is not displayed on the 7250A, but is printed by the printer. The seven digits displayed on the 7250A are 2SD-LSD.

521-31. There are six lines on which measurement data passes from the counter to the printer. Four of the lines (B1, B2, B4 and B8) transfer the measurement reading in BCD. The DP and UX lines are used to indicate when to insert the decimal point and the type of measurement unit.Table 521-1 shows an example of the format for the transmission of measurement data from a 7250A.

521-32. MAINTENANCE

521-33. Troubleshooting

521-34. If the printer does not print measurment data correctly, or if it does not print at all, first check the position of the address jumper on the Digital Interface PCB. Refer to the section on Moving the Address Jumper in the Operating Instructions.

521-35. If the printer still does not print data correctly, make sure the printer and counter are properly connected with cable Y7203 or Y7204. Apply power to the instruments, select desired settings, and apply a valid input signal to the counter. A non-burst mode must be selected for a 7220A. Use an oscilloscope and complete the procedure given in Table 521-2.

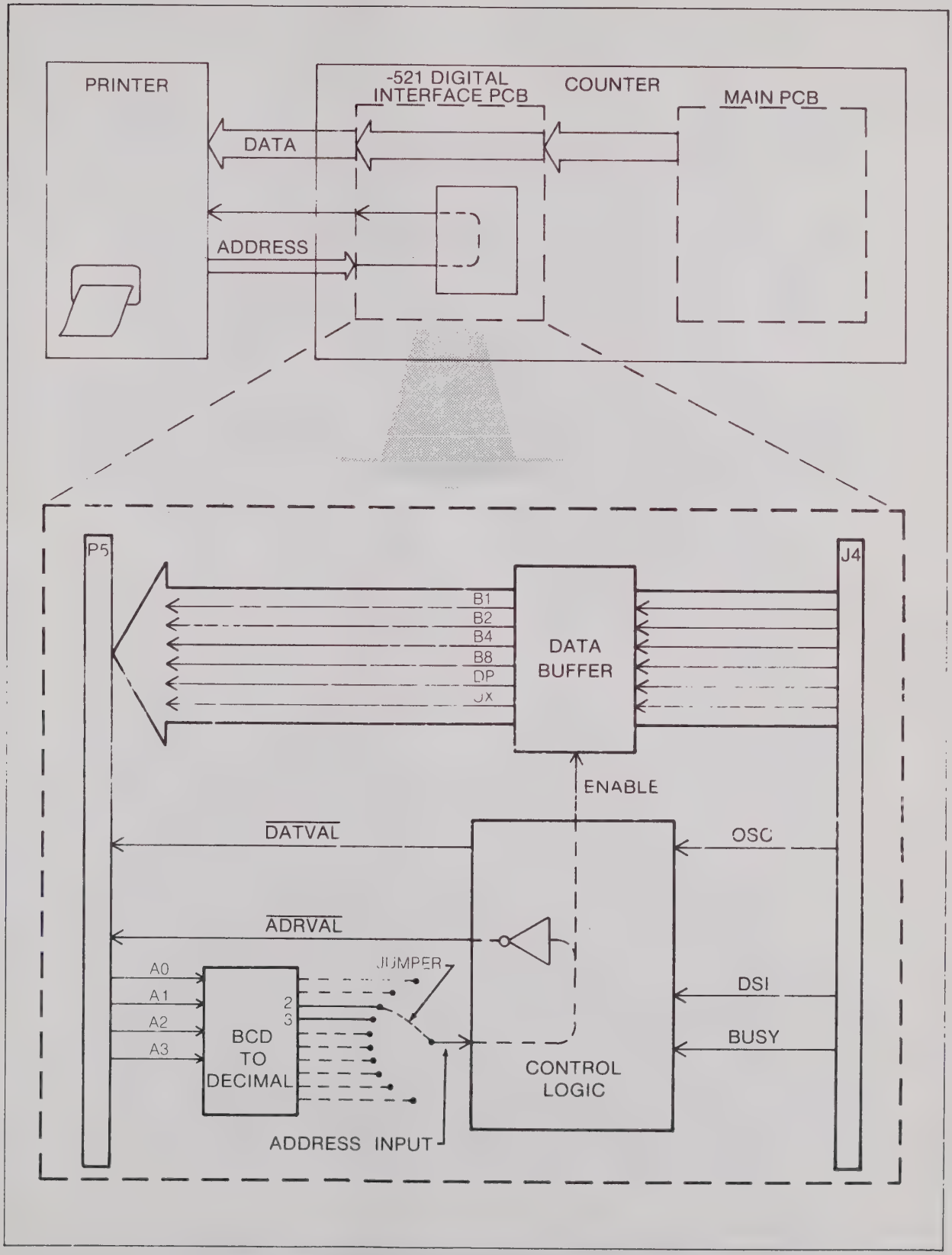
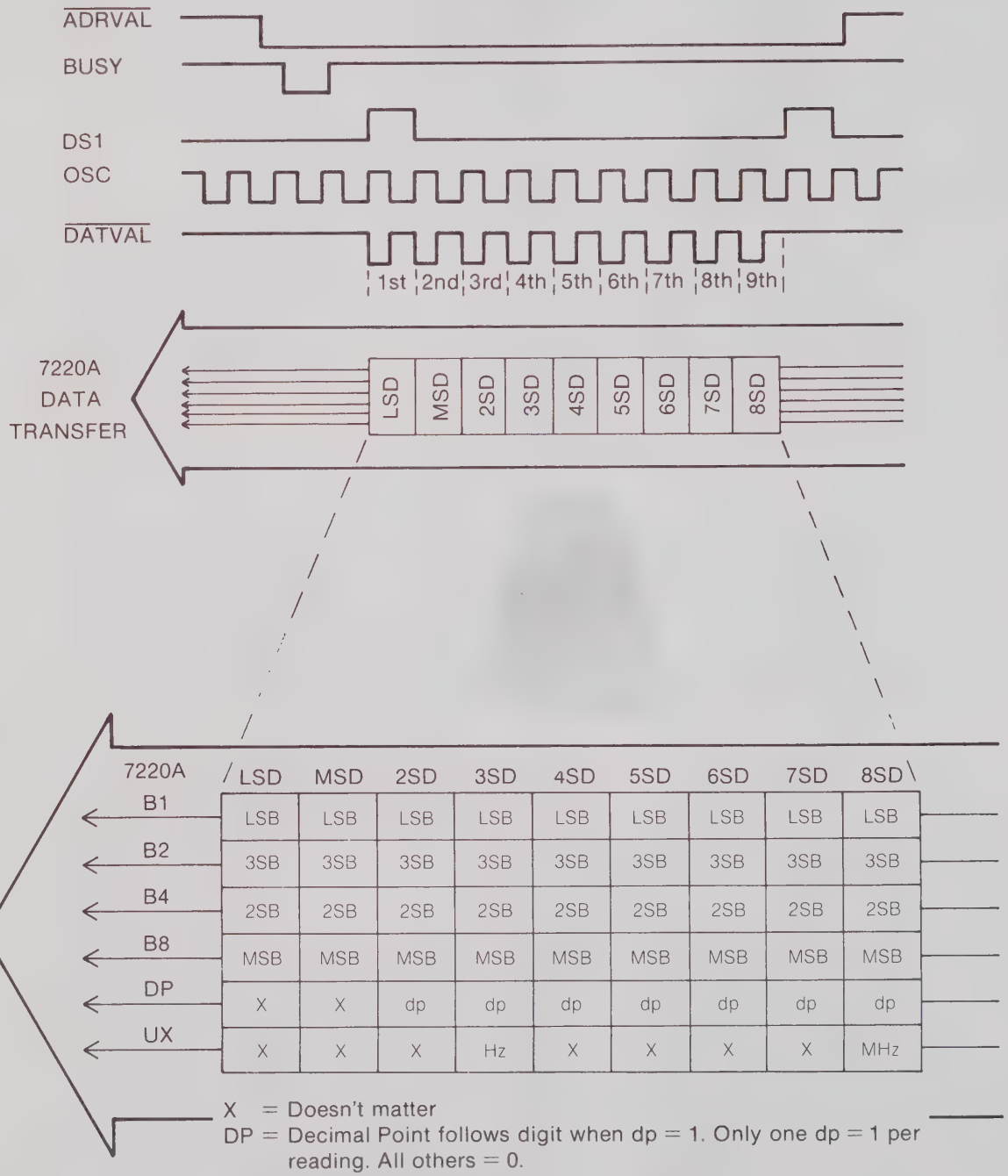


Figure 521-3 Interface Block Diagram


ADRVAL
BUSY
DS1
OSC
DATVAL
1st 2nd 3rd 4th 5th 6th 7th 8th 9th
7220A DATA TRANSFER
LSD MSD 2SD 3SD 4SD 5SD 6SD 7SD 8SD
7220A
LSD MSD 2SD 3SD 4SD 5SD 6SD 7SD 8SD
B1 LSB LSB LSB LSB LSB LSB LSB LSB LSB
B2 3SB 3SB 3SB 3SB 3SB 3SB 3SB 3SB 3SB
B4 2SB 2SB 2SB 2SB 2SB 2SB 2SB 2SB 2SB
B8 MSB MSB MSB MSB MSB MSB MSB MSB MSB
DP X X dp dp dp dp dp dp dp
UX X X X Hz X X X X MHz

X = Doesn't matter
DP = Decimal Point follows digit when dp = 1. Only one dp = 1 per reading. All others = 0.
UX = Measurement unit occurs as indicated when bit = 1. Only one UX bit = 1 per reading. All others = 0 or are ignored.

Figure 521-4. 7220A Data Transfer Format and Timing

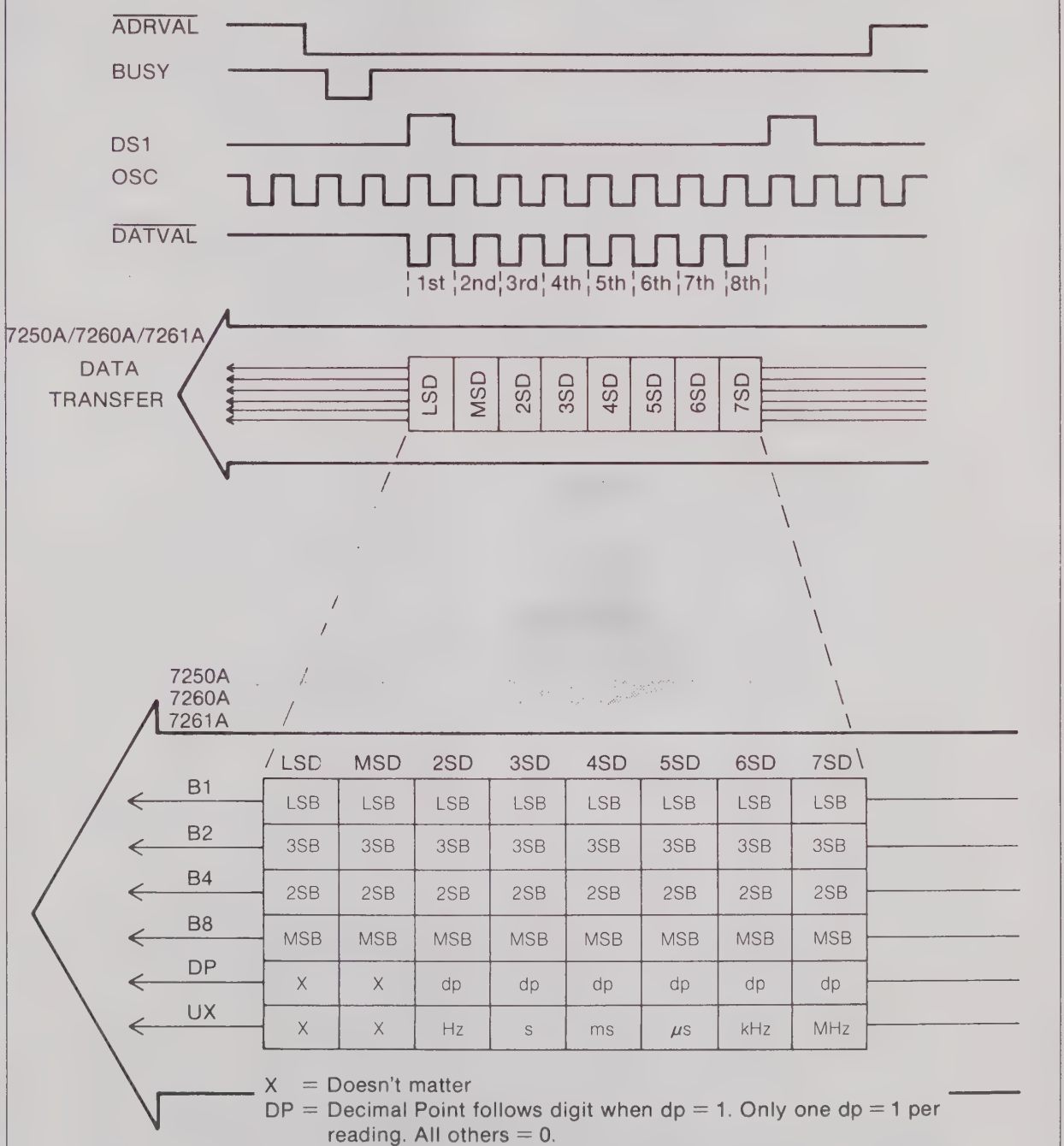

ADRVAL
BUSY
DS1
OSC
DATVAL
1st 2nd 3rd 4th 5th 6th 7th 8th
7250A/7260A/7261A
DATA
TRANSFER
LSD MSD 2SD 3SD 4SD 5SD 6SD 7SD
7250A
7260A
7261A
LSD MSD 2SD 3SD 4SD 5SD 6SD 7SD
B1 LSB LSB LSB LSB LSB LSB LSB LSB
B2 3SB 3SB 3SB 3SB 3SB 3SB 3SB 3SB
B4 2SB 2SB 2SB 2SB 2SB 2SB 2SB 2SB
B8 MSB MSB MSB MSB MSB MSB MSB MSB
DP X X dp dp dp dp dp dp
UX X X Hz s ms μs kHz MHz
X = Doesn't matter
DP = Decimal Point follows digit when dp = 1. Only one dp = 1 per reading. All others = 0.
UX = Measurement unit occurs as indicated when bit = 1. Only one UX bit = 1 per reading. All others = 0 or are ignored.

Figure 521-5. 7260A, 7261A, 7250A Data Transfer Format and Timing

Table 521-1. Data Format Example

7250A frequency measurement of 537.387 kHz made in the FREQ A mode with 1 Hz resolution.

	LSD	MSD	2SD	3SD	4SD	5SD	6SD	7SD
B1	1	0	0	1	1	1	1	0
B2	1	0	0	0	1	1	1	0
B4	1	0	0	1	0	1	0	0
B8	0	0	0	0	0	0	0	1
DP	x	x	0	0	0	1	0	0
UX	x	x	0	0	0	0	1	0

x=Doesn't matter

The printer output looks like this:

```
2      00537.387 kHz
```

Table 521-2. Troubleshooting Guide-Printer Interface

CHECK:		YOU SHOULD SEE:
Connector J4	Pin 2	+5V (supplied by counter)
Address Decode	U2-5	Positive pulse (CMOS) each time the printer addresses the counter.
U1 Buffer Enable	U3-4	Negative pulse, inverse of pulse on U2-5.
BUSY (BY)	U2-3	Pulses from counter indicating measurement is complete.
	U2-1	Positive pulse, one per print command. Occurs at completion of measurement.
	U2-11	Positive pulses, DSI from display.
	U2-13	Positive pulse, one per print command. Goes high at beginning of DSI, falls at beginning of next DSI.
$\overline{\text{DATVAL}}$	U4-11	Burst of 8 negative pulses (9 for the 7220A), one burst per print command.

521-36. Pin Assignment Table

521-37. Table 521-3 provides a list of the pin assignments for P5, which is the connection at the rear panel of the counter between the Digital Interface PCB and the cable to the printer. For pin assignments for J4, the connection between the Digital Interface PCB and the Main PCB of the counter, see the schematic in Section 8 of the Counter Instruction Manual.

521-38. REPLACEABLE PARTS

521-39. A detailed list of replaceable parts is presented in Table 521-4. Figure 521-6 can be used as an aid in locating components. Refer to Section 5 of the counter instruction manual for parts ordering information.

Table 521-3. P5 Pin Assignments.

P5 PIN NO.	MNEMONIC	SOURCE		DESCRIPTION
		COUNTER	PRINTER	
1	$\overline{\text{ADRVAL}}$	X		Address Valid
2	$\overline{\text{DATVAL}}$	X		Data Valid
3	A0		X	LSB (Counter Address)
4	A1		X	3SB (Counter Address)
5	A2		X	2SB (Counter Address)
6	A3		X	MSB (Counter Address)
7	not used			
8	not used			
9	D0	X		BCD Bit 1
10	D1	X		BCD Bit 2
11	D2	X		BCD Bit 4
12	D3	X		BCD Bit 8
13	D4	X		Decimal Point (DP)
14	D5	X		Measurement Unit (UX)
15	not used			
16	not used			
17	GND			
18	+5V Supplied by printer			
19-36	not used			

Note: $\overline{\text{BUSEN}}$ (pin no. 22) is always held high when the Printer Interface is used with a printer.

Table 521-4. Digital Interface (Option -521)

REF DES	DESCRIPTION	FLUKE STOCK NO.	MFG SPLY CODE	MFG PART NO. OR TYPE	TOT QTY	REC QTY	NOTE
	⊘ DIGITAL INTERFACE, OPTION-521 FIGURE 6521-6 (7220A-4007T)	ORDER	BY	OPTION -521	1		
J4	CONNECTOR, 36-PIN	484733	00779	87406-1	1		
P5	CONNECTOR, 36-PIN	479493	00779	552817-1	1		
RN1	RESISTOR NETWORK, 100K	461038	89536	461038	1	1	
U1⊘	IC, C-MOS, HEX NON INVET BUFFERS	407759	04713	MC14503CP	3	1	
U2⊘	IC, C-MOS, DUAL TYPE "D" FLIP-FLOP	340117	04713	MC14013CP	1	1	
U3⊘	IC, C-MOS, QUAD, 2-INPUT NAND GATES	355198	04713	MC14011CP	1	1	
U4	IC, TRI-STATE HEX BUFFER	483800	01295	SN74LS367N	1	1	
U5⊘	IC, C-MOS, BCD TO DECIMAL DECODER	380741	01295	TP4028AN	1	1	
U6	IC, LO-PWR, SCHOTTKY TRI-ST OCTAL, BFR.	429902	12040	DM81LS95N	1	1	
U7⊘	IC, C-MOS, HEX NON INVET BUFFERS	407759	04713	MC14503CP	REF		
U8⊘	IC, C-MOS, HEX NON INVET BUFFERS	407759	04713	MC14503CP	REF		
W1	PLUG, JUMPER	416842	91506	8136-651P2	1		
W1.	SOCKETS	376418	89536	376418	13		

NOTE: ⊘ Indicates the item can be damaged by static discharge.

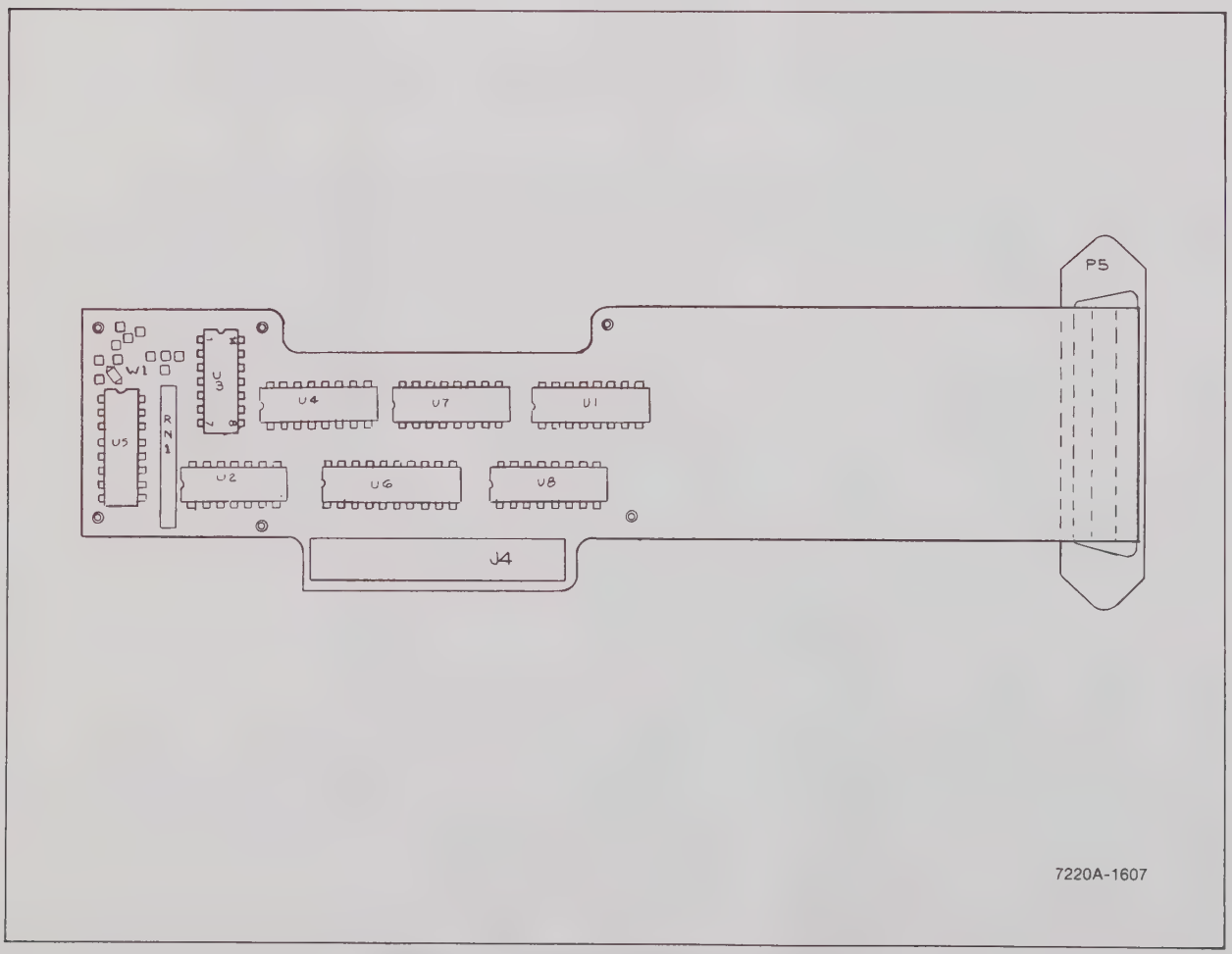


Figure 521-6. Digital Interface (Option -521)

Section 7

General Information

7-1. This section of the manual contains generalized user information as well as supplemental information to the List of Replaceable Parts contained in Section 5.

List of Abbreviations and Symbols

A or amp	ampere
ac	alternating current
af	audio frequency
a/d	analog-to-digital
assy	assembly
AWG	american wire gauge
B	bel
bcd	binary coded decimal
°C	Celsius
cap	capacitor
ccw	counterclockwise
cer	ceramic
cermet	ceramic to metal(seal)
ckt	circuit
cm	centimeter
cmrr	common mode rejection ratio
comp	composition
cont	continue
crt	cathode-ray tube
cw	clockwise
d/a	digital-to-analog
dac	digital-to-analog converter
dB	decibel
dc	direct current
dmm	digital multimeter
dvm	digital voltmeter
elect	electrolytic
ext	external
F	farad
°F	Fahrenheit
FET	Field-effect transistor
ff	flip-flop
freq	frequency
FSN	federal stock number
g	gram
G	giga (10^9)
gd	guard
Ge	germanium
GHz	gigahertz
gmv	guaranteed minimum value
gnd	ground
H	henry
hd	heavy duty
hf	high frequency
Hz	hertz
IC	integrated circuit
if	intermediate frequency
in	inch(es)
intl	internal
I/O	input/output
k	kilo (10^3)
kHz	kilohertz
kΩ	kilohm(s)
kV	kilovolt(s)
lf	low frequency
LED	light-emitting diode
LSB	least significant bit
LSD	least significant digit
M	mega (10^6)
m	milli (10^{-3})
mA	milliampere(s)
max	maximum
mf	metal film
MHz	megahertz
min	minimum
mm	millimeter
ms	millisecond
MSB	most significant bit
MSD	most significant digit
MTBF	mean time between failures
MTTR	mean time to repair
mV	millivolt(s)
mv	multivibrator
MΩ	megohm(s)
n	nano (10^{-9})
na	not applicable
NC	normally closed
(–) or neg	negative
NO	normally open
ns	nanosecond
opnl ampl	operational amplifier
p	pico (10^{-12})
para	paragraph
pcb	printed circuit board
pF	picofarad
pn	part number
(+) or pos	positive
pot	potentiometer
p-p	peak-to-peak
ppm	parts per million
PROM	programmable read-only memory
psi	pound-force per square inch
RAM	random-access memory
rf	radio frequency
rms	root mean square
ROM	read-only memory
s or sec	second (time)
scope	oscilloscope
SH	shield
Si	silicon
serno	serial number
sr	shift register
Ta	tantalum
tb	terminal board
tc	temperature coefficient or temperature compensating
tcxo	temperature compensated crystal oscillator
tp	test point
u or μ	micro (10^{-6})
uhf	ultra high frequency
us or μs	microsecond(s) (10^{-6})
uut	unit under test
V	volt
v	voltage
var	variable
vco	voltage controlled oscillator
vhf	very high frequency
vlf	very low frequency
W	watt(s)
ww	wire wound
xfmr	transformer
xstr	transistor
xtal	crystal
xtlo	crystal oscillator
Ω	ohm(s)
μ	micro (10^{-6})

Federal Supply Codes for Manufacturers

00213
Nytronics Comp. Group Inc.
Subsidiary of Nytronics Inc.
Formerly Sage Electronics
Rochester, New York

00327
Welwyn International, Inc.
Westlake, Ohio

00656
Aerovox Corp.
New Bedford, Massachusetts

00686
Film Capacitors, Inc.
Passaic, New Jersey

00779
AMP Inc.
Harrisburg, Pennsylvania

01121
Allen-Bradley Co.
Milwaukee, Wisconsin

01281
TRW Electronic Comp.
Semiconductor Operations
Lawndale, California

01295
Texas Instruments, Inc.
Semiconductor Group
Dallas, Texas

01537
Motorola Communications &
Electronics Inc.
Franklin Park, Illinois

01686
RCL Electronics Inc.
Manchester, New Hampshire

01730
Replaced by 73586

01884
Use 56289
Sprague Electric Co.
Dearborn Electronic Div.
Lockwood, Florida

02114
Ferroxcube Corp.
Saugerties, New York

02131
General Instrument Corp.
Harris ASW Div.
Westwood, Maine

02395
Rason Mfg. Co.
Brooklyn, New York

02533
Snelgrove, C.R. Co., Ltd.
Don Mills, Ontario, Canada
M3B 1M2

02606
Fenwal Labs
Div. of Travenal Labs.
Morton Grove, Illinois

02660
Bunker Ramo Corp., Conn Div.
Formerly Amphenol-Borg
Electric Corp.
Broadview, Illinois

02799
Areo Capacitors, Inc.
Chatsworth, California

03508
General Electric Co.
Semiconductor Products
Syracuse, New York

03614
Replaced by 71400

03651
Replaced by 44655

03797
Eldema Div.
Genisco Technology Corp.
Compton, California

03877
Transistron Electronic Corp.
Wakefield, Massachusetts

03888
KDI Pyrofilm Corp.
Whippany, New Jersey

03911
Clairex Electronics Div.
Clairex Corp.
Mt. Vernon, New York

03980
Muirhead Inc.
Mountainside, New Jersey

04009
Arrow Hart Inc.
Hartford, Connecticut

04062
Replaced by 72136

04202
Replaced by 81312

04217
Essex International Inc.
Wire & Cable Div.
Anaheim, California

04221
Aemco, Div. of
Midtex Inc.
Mankato, Minnesota

04222
AVX Ceramics Div.
AVX Corp.
Myrtle Beach, Florida

04423
Telonic Industries
Laguna Beach, California

04645
Replaced by 75376

04713
Motorola Inc. Semiconductor
Products
Phoenix, Arizona

04946
Standard Wire & Cable
Los Angeles, California

05082
Replaced by 94988

05236
Jonathan Mfg. Co.
Fullerton, California

05245
Components Corp. now
Corcom, Inc.
Chicago, Illinois

05277
Westinghouse Electric Corp.
Semiconductor Div.
Youngwood, Pennsylvania

05278
Replaced by 43543

05279
Southwest Machine &
Plastic Co.
Glendora, California

05397
Union Carbide Corp.
Materials Systems Div.
New York, New York

05571
Use 56289
Sprague Electric Co.
Pacific Div.
Los Angeles, California

05574
Viking Industries
Chatsworth, California

05704
Replaced by 16258

05820
Wakefield Engineering Inc.
Wakefield, Massachusetts

06001
General Electric Co.
Electronic Capacitor &
Battery Products Dept.
Columbia, South Carolina

06136
Replaced by 63743

06383
Panduit Corp.
Tinley Park, Illinois

06473
Bunker Ramo Corp.
Amphenol SAMS Div.
Chatsworth, California

06555
Beede Electrical Instrument Co.
Penacook, New Hampshire

06739
Electron Corp.
Littleton, Colorado

06743
Clevite Corp.
Cleveland, Ohio

06751
Components, Inc. Semcor Div.
Phoenix, Arizona

06860
Gould Automotive Div.
City of Industry, California

06961
Vernitron Corp., Piezo
Electric Div.
Formerly Clevite Corp., Piezo
Electric Div.
Bedford, Ohio

06980
Eimac Div.
Varian Associates
San Carlos, California

07047
The Ross Milton Co.
South Hampton, Pennsylvania

07115
Replaced by 14674

07138
Westinghouse Electric Corp.,
Electronic Tube Div.
Horsehead, New York

07233
TRW Electronic Components
Cinch Graphic
City of Industry, California

07256
Silicon Transistor Corp.
Div. of BBF Group Inc.
Chelmsford, Massachusetts

07261
Aumet Corp.
Culver City, California

07263
Fairchild Semiconductor
Div. of Fairchild Camera
& Instrument Corp.
Mountain View, California

07344
Bircher Co., Inc.
Rochester, New York

07597
Burndy Corp.
Tape/Cable Div.
Rochester, New York

07792
Lerma Engineering Corp.
Northampton, Massachusetts

07910
Teledyne Semiconductor
Formerly Continental Device
Hawthorne, California

07933
Use 49956
Raytheon Co.
Semiconductor Div. HQ
Mountain View, California

08225
Industro Transistor Corp.
Long Island City, New York

Federal Supply Codes for Manufacturers (cont)

08261
Spectra Strip Corp.
Garden Grove, California

08530
Reliance Mica Corp.
Brooklyn, New York

08806
General Electric Co.
Miniature Lamp Products Dept
Cleveland, Ohio

08863
Nylomatic Corp.
Norrisville, Pennsylvania

08988
Use 53085
Skottie Electronics Inc.
Archbald, Pennsylvania

09214
G.E. Co. Semi-Conductor
Products Dept.
Power Semi-Conductor
Products OPN Sec.
Auburn, New York

09353
C and K Components
Watertown, Massachusetts

09423
Scientific Components, Inc.
Santa Barbara, California

09922
Burndy Corp.
Norwalk, Connecticut

09969
Dale Electronics Inc.
Yankton, S. Dakota

10059
Barker Engineering Corp.
Formerly Amerace, Amerace
ESNA Corp.
Kenilworth, New Jersey

11236
CTS of Berne
Berne, Indiana

11237
CTS Keene Inc.
Paso Robles, California

11358
CBS Electronic Div.
Columbia Broadcasting System
Newburyport, Minnesota

11403
Best Products Co.
Chicago, Illinois

11503
Keystone Columbia Inc.
Warren, Michigan

11532
Teledyne Relays
Hawthorne, California

11711
General Instrument Corp.
Rectifier Division
Hicksville, New York

11726
Qualidyne Corp.
Santa Clara, California

12014
Chicago Rivet & Machine Co.
Bellwood, Illinois

12040
National Semiconductor Corp.
Danburry, Connecticut

12060
Diodes, Inc.
Chatsworth, California

12136
Philadelphia Handle Co.
Camden, New Jersey

12300
Potter-Brumfield Div.
AMF Canada LTD.
Guelph, Ontario, Canada

12323
Presin Co., Inc.
Shelton, Connecticut

12327
Freeway Corp. formerly
Freeway Washer & Stamping Co.
Cleveland, Ohio

12443
The Budd Co. Polychem Products
Plastic Products Div.
Bridgeport, Pennsylvania

12615
U.S. Terminals Inc.
Cincinnati, Ohio

12617
Hamlin Inc.
Lake Mills, Wisconsin

12697
Clarostat Mfg. Co.
Dover, New Hampshire

12749
James Electronics
Chicago, Illinois

12856
Micrometals
Sierra Madre, California

12954
Dickson Electronics Corp.
Scottsdale, Arizona

12969
Unitrode Corp.
Watertown, Massachusetts

13103
Thermalloy Co., Inc.
Dallas, Texas

13327
Solitron Devices Inc.
Tappan, New York

13511
Amphenol Cadre Div.
Bunker-Ramo Corp.
Los Gatos, California

13606
Use 56289
Sprague Electric Co.
Transistor Div.
Concord, New Hampshire

13839
Replaced by 23732

14099
Semtech Corp.
Newbury Park, California

14140
Edison Electronic Div.
Mc Gray-Edison Co.
Manchester, New Hampshire

14193
Cal-R-Inc. formerly
California Resistor, Corp.
Santa Monica, California

14298
American Components, Inc.
an Insilco Co.
Conshohocken, Pennsylvania

14655
Cornell-Dublier Electronics
Division of Federal Pacific
Electric Co. Govt. Control Dept.
Newark, New Jersey

14752
Electro Cube Inc.
San Gabriel, California

14869
Replaced by 96853

14936
General Instrument Corp.
Semi Conductor Products Group
Hicksville, New York

15636
Elec-Trol Inc.
Saugus, California

15801
Fenwal Electronics Inc.
Div. of Kidde Walter and Co., Inc.
Framingham, Massachusetts

15818
Teledyne Semiconductors,
formerly Amelco Semiconductor
Mountain View, California

15849
Litton Systems Inc. Useco Div.
formerly Useco Inc.
Van Nuys, California

15898
International Business
Machines Corp.
Essex Junction, Vermont

15909
Replaced by 14140

16258
Space-Lok Inc.
Burbank, California

16299
Corning Glass
Electronic Components Div.
Raleigh, North Carolina

16332
Replaced by 28478

16473
Cambridge Scientific Ind.
Div. of Chemed Corporation
Cambridge, Maryland

16742
Paramount Plastics
Fabricators, Inc.
Downey, Caiifornia

16758
Delco Electronics
Div. of General Motors Corp.
Kokomo, Indiana

17001
Replaced by 71468

17069
Circuit Structures Lab.
Burbank, California

17338
High Pressure Eng. Co., Inc.
Oklahoma City, Oklahoma

17545
Atlantic Semiconductors, Inc.
Asbury Park, New Jersey

17856
Siliconix, Inc.
Santa Clara, California

17870
Replaced by 14140

18178
Vactec Inc.
Maryland Heights, Missouri

18324
Signetics Corp.
Sunnyvale, California

18612
Vishay Resistor Products Div.
Vishay Intertechnology Inc.
Malvern, Pennsylvania

18736
Voltronics Corp.
Hanover, New Jersey

18927
GTE Sylvania Inc.
Precision Material Group
Parts Division
Titusville, Pennsylvania

19451
Perine Machinery & Supply Co.
Seattle, Washington

19701
Electro-Midland Corp.
Mepco-Electra Inc.
Mineral Wells, Texas

20584
Enochs Mfg. Inc.
Indianapolis, Indiana

Federal Supply Codes for Manufacturers (cont)

20891
Self-Organizing Systems, Inc.
Dallas, Texas

21604
Bucheye Stamping Co.
Columbus, Ohio

21845
Solitron Devices Inc.
Transistor Division
Riveria Beach, Florida

22767
ITT Semiconductors
Palo Alto, California

23050
Product Comp. Corp.
Mount Vernon, New York

23732
Tracor Inc.
Rockville, Maryland

23880
Stanford Applied Engrng.
Santa Clara, California

23936
Pamotor Div., Wm. J. Purdy Co.
Burlingame, California

24248
Replaced by 94222

24355
Analog Devices Inc.
Norwood, Massachusetts

24655
General Radio
Concord, Massachusetts

24759
Lenox-Fugle Electronics Inc.
South Plainfield, New Jersey

25088
Siemen Corp.
Isilen, New Jersey

25403
Amperex Electronic Corp.
Semiconductor &
Micro-Circuits Div.
Slatersville, Rhode Island

27014
National Semiconductor Corp.
Santa Clara, California

27264
Molex Products
Downers Grove, Illinois

28213
Minnesota Mining & Mfg. Co.
Consumer Products Div.
St. Paul, Minnesota

28425
Serv-/-Link formerly
Bohannan Industries
Fort Worth, Texas

28478
Deltrol Controls Div.
Deltrol Corporation
Milwaukee, Wisconsin

28480
Hewlett Packard Co.
Corporate HQ
Palo Alto, California

28520
Heyman Mfg. Co.
Kenilworth, New Jersey

29083
Monsanto, Co., Inc.
Santa Clara, California

29604
Stackpole Components Co.
Raleigh, North Carolina

30148
AB Enterprise Inc.
Ahoskie, North Carolina

30323
Illinois Tool Works, Inc.
Chicago, Illinois

31091
Optimax Inc.
Colmar, Pennsylvania

32539
Mura Corp.
Great Neck, New York

32767
Griffith Plastic Corp.
Burlingame, California

32879
Advanced Mechanical
Components
Northridge, California

32897
Erie Technological Products, Inc.
Frequency Control Div.
Carlisle, Pennsylvania

32997
Bourns Inc.
Trimpot Products Division
Riverside, California

33173
General Electric Co.
Products Dept.
Owensboro, Kentucky

34333
Silicon General
Westminister, California

34335
Advanced Micro Devices
Sunnyvale, California

34802
Electromotive Inc.
Kenilworth, New Jersey

37942
P.R. Mallory & Co., Inc.
Indianapolis, Indiana

42498
National Radio
Melrose, Massachusetts

43543
Nytronics Inc.
Transformer Co. Div.
Geneva, New York

44655
Ohmite Mfg. Co.
Skokie, Illinois

49671
RCA Corp.
New York, New York

49956
Raytheon Company
Lexington, Massachusetts

50088
Mostek Corp.
Carrollton, Texas

50579
Litronix Inc.
Cupertino, California

51605
Scientific Components Inc.
Linden, New Jersey

53021
Sangamo Electric Co.
Springfield, Illinois

54294
Cutler-Hammer Inc. formerly
Shallcross, A Cutter-Hammer Co.
Selma, North Carolina

55026
Simpson Electric Co.
Div. of Am. Gage and Mach. Co.
Elgin, Illinois

56289
Sprague Electric Co.
North Adams, Massachusetts

58474
Superior Electric Co.
Bristol, Connecticut

60399
Torin Corp. formerly
Torrington Mfg. Co.
Torrington, Connecticut

63743
Ward Leonard Electric Co., Inc.
Mount Vernon, New York

64834
West Mfg. Co.
San Francisco, California

65092
Weston Instruments Inc.
Newark, New Jersey

66150
Winslow Tele-Tronics Inc.
Eaton Town, New Jersey

70485
Atlantic India Rubber Works
Chicago, Illinois

70563
Amperite Company
Union City, New Jersey

70903
Belden Corp.
Geneva, Illinois

71002
Birnback Radio Co., Inc.
Freeport, New York

71400
Bussmann Mfg.
Div. of McGraw-Edison Co.
Saint Louis, Missouri

71450
CTS Corp.
Elkhart, Indiana

71468
ITT Cannon Electric Inc.
Santa Ana, California

71482
Clare, C.P. & Co.
Chicago, Illinois

71590
Centrelab Electronics
Div. of Globe Union Inc.
Milwaukee, Wisconsin

71707
Coto Coil Co., Inc.
Providence, Rhode Island

71744
Chicago Miniature Lamp Works
Chicago, Illinois

71785
TRW Electronics Components
Cinch Connector Operations Div.
Elk Grove Village
Chicago, Illinois

72005
Wilber B. Driver Co.
Newark, New Jersey

72092
Replaced by 06980

72136
Electro Motive Mfg. Co.
Williamantic, Connecticut

72259
Nytronics Inc.
Pelham Manor, New Jersey

72619
Dialight Div.
Amperex Electronic Corp.
Brooklyn, New York

72653
G.C. Electronics
Div. of Hydrometals, Inc.
Brooklyn, New York

72665
Replaced by 90303

72794
Dzus Fastener Co., Inc.
West Islip, New York

72928
Gulton Ind. Inc.
Gudeman Div.
Chicago, Illinois

Federal Supply Codes for Manufacturers (cont)

72982
Erie Tech. Products Inc.
Erie, Pennsylvania

73138
Bechman Instrument Inc.
Helipot Division
Fullerton, California

73293
Hughes Aircraft Co.
Electron Dynamics Div.
Torrance, California

73445
Amperex Electronic Corp.
Hicksville, New York

73559
Carling Electric Inc.
West Hartford, Connecticut

73586
Circle F Industries
Trenton, New Jersey

73734
Federal Screw Products, Inc.
Chicago, Illinois

73743
Fischer Special Mfg. Co.
Cincinnati, Ohio

73899
JFD Electronics Co.
Components Corp.
Brooklyn, New York

73949
Guardian Electric Mfg. Co.
Chicago, Illinois

74199
Quan Nichols Co.
Chicago, Illinois

74217
Radio Switch Corp.
Marlboro, New Jersey

74276
Signalite Div.
General Instrument Corp.
Neptune, New Jersey

74306
Piezo Crystal Co.
Carlisle, Pennsylvania

74542
Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970
Johnson E.F., Co.
Waseca, Minnesota

75042
TRW Electronics Components
IRC Fixed Resistors
Philadelphia, Pennsylvania

75376
Kurz-Kasch Inc.
Dayton, Ohio

75378
CTS Knights Inc.
Sandwich, Illinois

75382
Kulka Electric Corp.
Mount Vernon, New York

75915
Littlefuse Inc.
Des Plaines, Illinois

76854
Oak Industries Inc.
Switch Div.
Crystal Lake, Illinois

77342
AMF Inc.
Potter & Brumfield Div.
Princeton, Indiana

77638
General Instrument Corp.
Rectifier Division
Brooklyn, New York

77969
Rubbercraft Corp. of CA. LTD.
Torrance, California

78189
Shakeproof
Div. of Illinois Tool Works Inc.
Elgin, Illinois

78277
Sigma Instruments, Inc.
South Braintree, Massachusetts

78488
Stackpole Carbon Co.
Saint Marys, Pennsylvania

78553
Eaton Corp. Engineered
Fastener Div.
Tinnerman Plant
Cleveland, Ohio

79136
Waldes Kohinoor Inc.
Long Island City, New York

79497
Western Rubber Company
Goshen, Indiana

79963
Zierick Mfg. Corp.
Mt. Kisko, New York

80031
Electro-Midland Corp.
Mepco Div.
A North American Phillips Co.
Norristown, New Jersey

80145
LFE Corp., Process Control Div.
formerly API Instrument Co.
Chesterland, Ohio

80183
Use 56289
Sprague Products
North Adams, Massachusetts

80294
Bourns Inc., Instrument Div.
Riverside, California

80583
Hammarlund Mfg. Co., Inc.
Red Bank, New Jersey

80640
Arnold Stevens, Inc.
South Boston, Massachusetts

81073
Grayhill, Inc.
La Grange, Illinois

81312
Winchester Electronics
Div. of Litton Industries Inc.
Oakville, Connecticut

81483
Therm-O-Disc Inc.
Mansfield, Ohio

81483
International Rectifier Corp.
Los Angeles, California

81590
Korry Mfg. Co.
Seattle, Washington

81741
Chicago Lock Co.
Chicago, Illinois

82305
Palmer Electronics Corp.
South Gate, California

82389
Switchcraft Inc.
Chicago, Illinois

82415
North American Phillips
Controls Corp.
Frederick, Maryland

82872
Roanwell Corp.
New York, New York

82877
Rotron Inc.
Woodstock, New York

82879
ITT Royal Electric Div.
Pawtucket, Rhode Island

83003
Varo Inc.
Garland, Texas

83058
The Carr Co., United Can Div.
of TRW
Cambridge, Massachusetts

83298
Bendix Corp.
Electric Power Div.
Eatontown, New Jersey

83330
Herman H. Smith, Inc.
Brooklyn, New York

83478
Rubbercraft Corp.
of America, Inc.
West Haven, Connecticut

83594
Burroughs Corp.
Electronic Components Div.
Plainfield, New Jersey

83740
Union Carbide Corp.
Battery Products Div.
formerly Consumer Products Div.
New York, New York

84171
Arco Electronics
Great Neck, New York

84411
TRW Electronic Components
TRW Capacitors
Ogallala, Nebraska

84613
Fuse Indicator Corp.
Rockville, Maryland

84682
Essex International Inc.
Industrial Wire Div.
Peabody, Massachusetts

86577
Precision Metal Products
of Malden Inc.
Stoneham, Massachusetts

86684
Radio Corp. of America
Electronic Components Div.
Harrison, New Jersey

86928
Seastrom Mfg. Co., Inc.
Glendale, California

87034
Illuminated Products Inc.
Subsidiary of Oak Industries Inc.
Anahiem, California

88219
Gould Inc.
Industrial Div.
Trenton, New Jersey

88245
Litton Systems Inc.
Useco Div.
Van Nuys, California

88419
Cornell-Dubilier Electronic Div.
Federal Pacific Co.
Fuquay-Varian, North Carolina

88486
Plastic Wire & Cable
Jewitt City, Connecticut

88690
Replaced by 04217

89536
John Fluke Mfg. Co., Inc.
Seattle, Washington

89730
G.E. Co., Newark Lamp Works
Newark, New Jersey

Federal Supply Codes for Manufacturers (cont)

90201
Mallory Capacitor Co.
Div. of P.R. Mallory Co., Inc.
Indianapolis, Indiana

90211
Use 56365
Square D Co.
Chicago, Illinois

90215
Best Stamp & Mfg. Co.
Kansas City, Missouri

90303
Mallory Battery Co.
Div. of Mallory Co., Inc.
Tarrytown, New York

91094
Essex International Inc.
Suglex/IWP Div.
Newmarket, New Hampshire

91293
Johanson Mfg. Co.
Boonton, New Jersey

91407
Replaced by 58474

91502
Associated Machine
Santa Clara, California

91506
Augat Inc.
Attleboro, Massachusetts

91637
Dale Electronics Inc.
Columbus, Nebraska

91662
Elco Corp.
Willow Grove, Pennsylvania

91737
Use 71468
Gremar Mfg. Co., Inc.
ITT Cannon/Gremar
Santa Ana, California

91802
Industrial Devices, Inc.
Edgewater, New Jersey

91833
Keystone Electronics Corp.
New York, New York

91836
King's Electronics Co., Inc.
Tuckahoe, New York

91929
Honeywell Inc.
Micro Switch Div.
Freeport, Illinois

91934
Miller Electric Co., Inc.
Div. of Aunet
Woonsocket, Rhode Island

92194
Alpha Wire Corp.
Elizabeth, New Jersey

93332
Sylvania Electric Products
Semiconductor Products Div.
Woburn, Massachusetts

94145
Replaced by 49956

94154
Use 94988
Wagner Electric Corp.
Tung-Sol Div.
Newark, New Jersey

94222
Southco Inc. formerly
South Chester Corp.
Lester, Pennsylvania

95146
Alco Electronic Products Inc.
Lawrence, Massachusetts

95263
Leecraft Mfg. Co.
Long Island City, New York

95264
Replaced by 98278

95275
Vitramon Inc.
Bridgeport, Connecticut

95303
RCA Corp.
Receiving Tube Div.
Cincinnati, Ohio

95348
Gordo's Corp.
Bloomfield, New Jersey

95354
Methode Mfg. Corp.
Rolling Meadows, Illinois

95712
Bendix Corp.
Electrical Components Div.
Microwave Devices Plant
Franklin, Indiana

95987
Weckesser Co. Inc.
Chicago, Illinois

96733
San Fernando Electric Mfg. Co.
San Fernando, California

96853
Gulton Industries Inc.
Measurement and Controls Div.
formerly Rustrak Instruments Co.
Manchester, New Hampshire

96881
Thomson Industries, Inc.
Manhasset, New York

97540
Master Mobile Mounts, Div. of
Whitehall Electronics Corp.
Ft. Meyers, Florida

97913
Industrial Electronic
Hardware Corp.
New York, New York

97945
Penwalt Corp.
SS White Industrial Products Div.
Piscataway, New Jersey

97966
Replaced by 11358

98094
Replaced by 49956

98159
Rubber-Teck, Inc.
Gardena, California

98278
Malco A Microdot Co., Inc.
Connector & Cable Div.
Pasadena, California

98291
Sealectro Corp.
Mamaroneck, New York

98388
Royal Industries
Products Div.
San Diego, California

98743
Replaced by 12749

98925
Replaced by 14433

99120
Plastic Capacitors, Inc.
Chicago, Illinois

99217
Bell Industries Elect.
Comp. Div.
formerly Southern Elect. Div.
Burbank, California

99392
STM
Oakland, California

99515
ITT Jennings Monrovia Plant
Div. of ITT Jennings formerly
Marshall Industries Capacitor Div.
Monrovia, California

99779
Use 29587
Bunker-Ramo Corp.
Barnes Div.
Landsdowne, Pennsylvania

99800
American Precision Industries Inc.
Delevan Division
East Aurora, New York

99942
Centrelab Semiconductor
Centrelab Electronics Div. of
Globe-Union Inc.
El Monte, California

Toyo Electronics
(R-Ohm Corp.)
Irvine, California

National Connector
Minneapolis, Minnesota

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(907) 279-5741

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Suite 96
Huntsville, AL 35801
(205) 881-6220

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Tustin, CA 92680
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(303) 750-1222

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41-C New London Turnpike
Glastonbury, CT 06033
(203) 659-3541

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John Fluke Mfg. Co.,Inc.
940 N. Fern Creek Ave.
Orlando, FL 32803
(305) 896-4881

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John Fluke Mfg. Co., Inc.
2700 Delk Rd., Suite 250
Marietta, GA 30067
(404) 953-4747

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EMC Corporation
2979 Ualena St.
Honolulu, HI 96819
(808) 836-1138

IA, Iowa City
(319) 354-2811

IL, Chicago
John Fluke Mfg. Co., Inc.
3740 Industrial Ave.
Rolling Meadows, IL 60008
(312) 398-0850

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John Fluke Mfg. Co., Inc.
877 Purdue
Suite 101
Indianapolis, IN 46268
(317) 875-7870

KS, Kansas City
John Fluke Mfg. Co., Inc.
4550 W. 109th St., Suite 130
Shawnee Mission, KA 66211
(913) 381-9800

LA, New Orleans
(504) 455-0814

MA, Burlington
John Fluke Mfg. Co., Inc.
25 "B" Street
Burlington MA 01803
(617) 273-4674

MD, Baltimore
(301) 792-7060

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John Fluke Mfg. Co., Inc.
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Rockville, MD 20852
(301) 770-1570

MI, Detroit
John Fluke Mfg. Co., Inc.
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Livonia, MI 48154
(313) 522-9140

MN, Bloomington
John Fluke Mfg. Co., Inc.
1801 E. 79th St., Suite 9
Bloomington, MN 55420
(612) 854-5526

MO, St. Louis
John Fluke Mfg. Co., Inc.
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Suite 105
St. Louis, MO 63141
(314) 993-3805

NC, Greensboro
John Fluke Mfg. Co., Inc.
1310 Beaman Place
Greensboro, NC 27408
(919) 273-1918

NJ, Paramus
John Fluke Mfg. Co., Inc.
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West 75 Century Road
Paramus, NJ 07652
(201) 262-9550

NM, Albuquerque
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1108 Alvarado Drive N.E.
Albuquerque, NM 87110
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7830 Freeway Circle
Middleburg Heights, OH 44130
(216) 234-4540

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John Fluke Mfg. Co., Inc.
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Dayton, OH 45424
(513) 233-2238

OR, Portland
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Aloha, OR 97007
(503) 642-1342

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John Fluke Mfg. Co., Inc.
1010 West 8th Ave., Suite H
King of Prussia, PA 19406
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8705 Shoal Creek Blvd.
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Dallas
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14400 Midway Road
Dallas, TX 75234
(214) 233-9990

Houston
John Fluke Mfg. Co., Inc.
4240 Blue Bonnet Dr.
Stafford, TX 77477
(713) 491-5995

San Antonio
John Fluke Mfg. Co., Inc.
10417 Gulfdale
San Antonio, TX 78216
(512) 340-2621

UT, Salt Lake City
John Fluke Mfg. Co., Inc.
5226 So. 300 West, Suite #2
Salt Lake City, UT 84107
(801) 268-9331

WA, Seattle
John Fluke Mfg. Co., Inc.
5020 148th Ave. N.E.
Suite #110
Redmond, WA 98052
(206) 881-6966

Service Center Areas

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FL, Orlando (305) 896-2296
IL, Chicago (312) 398-5800
MA, Burlington (617) 273-4678
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Vienna, Austria
Tel. (0222) 235555, TLX: 134759

Bangladesh ●
Motherland Corporation
24 Hatkhola Rd., Tikatuli
Dacca 3, Bangladesh
Tel: 257249 or 255776

Belgium ■
Fluke (Belgium) S.A./N.V.
6, Rue de Geneve
1140 Brussels, Belgium
Tel: (2) 2164090, TLX: 26312

Bolivia ●
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Casilla 7295, La Paz, Bolivia
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Fluke Brasil-Industria E
Commercio LTDA
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Alphaville, Barueri,
CEP 06400 Sao Paulo, Brazil
Tel: (011) 421-5477, TLX: 01135589

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Tel: 252-1297

Brunei ●
Rank O'Connor's (PTE) Limited
No. 8, BK.D
Surfri Shop House Complex
Mile 1, Jalong Tutong
Bandar Seri Begawan, Brunei
Tel. 26680

Bulgaria ■
Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Canada ●
Allan Crawford Assoc., Ltd.
#14 1935 30th Ave. N.E.
Calgary, Alberta T2E 6Z5
Tel: (403) 230-1341, TLX: 03-821186

Allan Crawford Assoc., Ltd.
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Edmonton, Alberta T5L 4K1
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Tel: (416) 678-1500, TLX: 06968769

Allan Crawford Assoc., Ltd
7918 cote de Liesse
St. Laurent, Quebec H4T 1E7
Tel: (514) 731-8564, TLX: 05824944

Chad ■
Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Chile ●
Intronica Chile Ltda
Manuel Montt 024 - Of. D
Casilla 16228, Santiago 9, Chile
Tel: 44940, TLX: 240301
Attn: Intronica Chile

China, People's Republic of ●
Fluke International Corporation
P.O. Box C9090
Everett, WA 98206, U.S.A.
Tel: (206) 356-5511
TLX: 152662 JOHN FLUKE EVT

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Sistemas E Instrumentacion, Ltda.
Carrera 13, No. 37-43, Of. 401
Ap. Aereo 29583
Bogota DE, Colombia SA
Tel: 232-45-32, TLX: 45787

Cyprus ■
Chris Radiovision Ltd
P.O. Box 1989, Nicosia, Cyprus
Tel: 66121, TLX: 8262395

Czechoslovakia ■
Amtest Associates Ltd.
Clarence House, 31, Clarence St.
Staines, Middlesex TW18 4SY
United Kingdom
Tel: (784) 63555, TLX: 928855

Denmark ■
Tage Olsen A/S
Ballerup Byvej 222
DK - 2750 Ballerup, Denmark
Tel: (2) 658111, TLX: (855) 35293

Ecuador ●
Proteco Coasin Cia., Ltda.
Edificio "Jerico"
Ave. 12 de Octubre #2285 y
Ave. Orellana (Planta Baja)
Quito, Ecuador
Tel: 529684, TLX: (393) 2865

Proteco Coasin Cia., Ltda.
Calderon 103 y Malecon
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Guayaquil, Ecuador
Tel: 526093

Egypt and Sudan ■
Electronic Engineering Liaison Office
P.O. Box 2891 Horreya
Heliopolis, Cairo, Egypt
Tel: 691588, TLX: (927) 92502

England ■
Fluke (Great Britain) LTD.
Colonial Way
Watford, Herts, WD2 4TT
United Kingdom
Tel: (0923) 40511, TLX: (851) 934583
Rapifax: (0923) 25067

Ethiopia ■
Fluke (Holland) B.V.
P.O. Box 5053, 5004 EB Tilburg
Zevenheuvelenweg 53, 5048 AN Tilburg
The Netherlands
Tel: (013) 673973, TLX: 52237

Fiji ●
AWA Fiji
47 Forster Road, Walu Bay
Suva, Fiji
Tel: 312079, TLX: FJ2347

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Tel: 811316, TLX: 112326

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Bangalore 560 080, India
Tel: 33139, TLX: (953) 0845741

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New Delhi, 110019, India
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Hinditron Services Pvt. Ltd.
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The Netherlands

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Sultanate of Oman
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TLX 3168

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Spark Radio & Electronics Corp
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San Juan, Metro-Manila
Philippines Zip 3113
Tel. 77-51-92

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United Kingdom
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Decada-Equipamentos de
Electronica, Lda
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Tel 321431, TLX (957) 4581

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TLX (831) 22404

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Colombo 5, Sri Lanka
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Damascus, Syria

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Taipei, Taiwan
Tel: 5414600. TLX: 11111

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John Fluke Mfg. Co., Inc., P.O. Box C9090, Everett, WA 98206
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Appendix 7A

Manual Change Information

INTRODUCTION

This appendix contains information necessary to backdate the manual to conform with earlier pcb configurations. To identify the configuration of the pcb's used in your instrument, refer to the revision letter (marked in ink) on the component side of each pcb assembly. Table 7A-1 defines the assembly revision levels documented in this manual.

NEWER INSTRUMENTS

As changes and improvements are made to the instrument, they are identified by incrementing the revision letter marked on the affected pcb assembly. These changes are documented on a supplemental change/errata sheet which, when applicable, is inserted at the front of the manual.

OLDER INSTRUMENTS

To backdate this manual to conform with earlier assembly revision levels, perform the changes indicated in Table 7A-1.

CHANGES

There are no backdating changes at this printing. All pcb assemblies are documented at their original revision level.

Table 7A-1. Manual Status and Backdating Information

Ref Or Option No.	Assembly Name	Fluke Part No.	* To adapt manual to earlier rev configurations perform changes in desending order (by no.), ending with change under desired rev letter																						
			–	A	B	C	D	E	F	G	H	J	K	L	M	N	P									
A1	Main PCB Assy	471540	●	●	●	●	●	●	●	●	X														
A2	Front Panel PCB Assy	471516	●	●	●	●	●	●	●	●	●	●	●	X											
A3	Timebase PCB Assy	406918	●	●	X																				
A3	Timebase PCB Assy	538660	X																						
-010	Battery Option	475962	●	●	●	●	●	●	X																
-111	1 PPM TCXO Option		X																						
-131	Low Power Oven Time Base Option	516112	●	X																					
-132	Sup. Low Power Oven Time Base Option	516096	●	X																					
-351	Resolution Multiplier Option	481747	X																						
-521	Digital Interface Option	487454	●	●	●	●	X																		

* X = The PCB revision levels documented in this manual.
● = These revision letters were never used in the instrument.
–= No revision letter on the PCB.

Section 8
Schematic Diagrams

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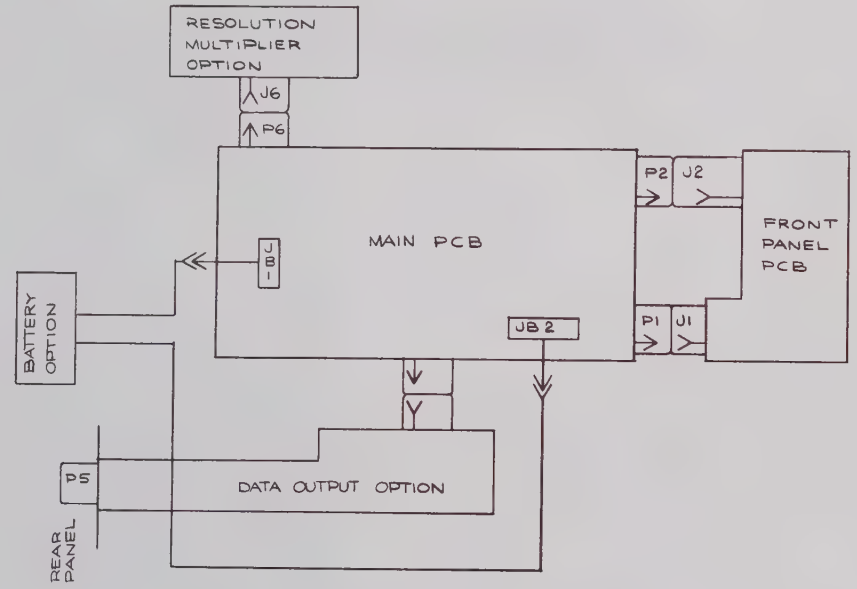
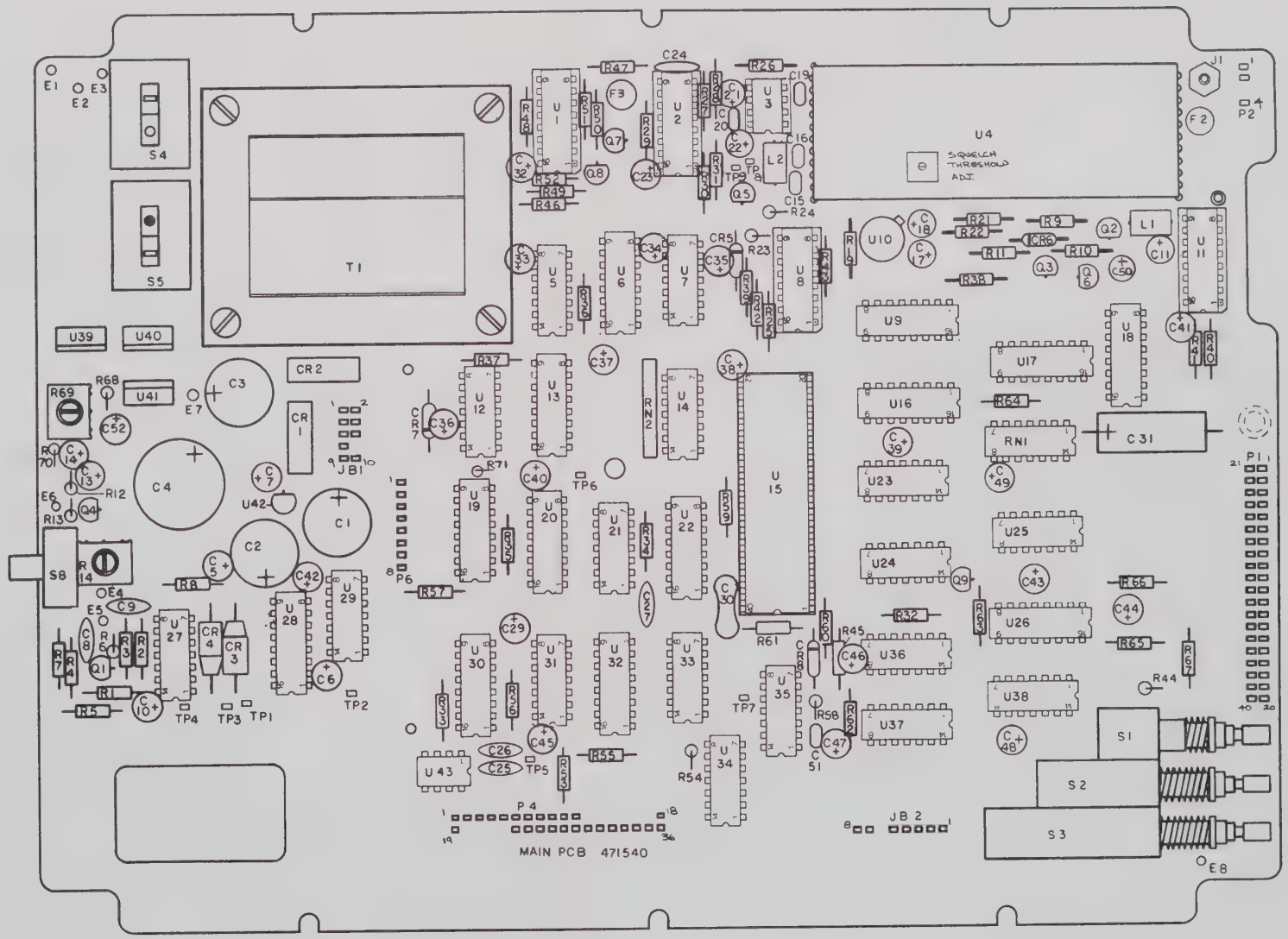
MNEMONICS

a, b, c, d, e, f, g	7 segment LED display information.
$\overline{\text{ADRVAL}}$	Address Valid. Printer interface signal.
AECL	Channel A Emitter-Coupled Logic.
ATTL	Channel A Transistor-Transistor Logic.
$\overline{\text{ATN}}$	Attention. IEEE Bus management line.
B1, B2, B4, B8	Binary coded decimal measurement bits from multiplexer to Digital Interface.
B1D1, B2D1, B3D1, B4D1	Binary coded decimal bits for digit 1.
B1D2, B2D2, B3D2, B4D2	Binary coded decimal bits for digit 2.
$\overline{\text{BE}}$	Channel B Enable.
$\overline{\text{BECL}}$	Channel B Emitter-Coupled Logic.
BST	BURST mode selected.
$\overline{\text{BUSEN}}$	Bus Enable.
BUSY, BY	Busy signal from Control Logic when measurement cycle is in progress.
CH A	Channel A mode selected.
CH B	Channel B mode selected.
CHK	Self-check mode selected.
D1, D2, D3, D4	Binary coded decimal measurement bits.
$\overline{\text{D1 01}}$ through $\overline{\text{D1 08}}$	IEEE data lines.
DAC	Data Accepted.
$\overline{\text{DAV}}$	Data Valid. IEEE handshake line.
$\overline{\text{DATVAL}}$	Data Valid. Printer Interface signal.
DP	Decimal Point.
DP1, DP2, DP3, DP4	Decimal point display position.
DET OUT	Detector Out from hybrid.
DET REF	Detector Reference from hybrid.
DS1 through DS8	Digit Strobe 1 through Digit Strobe 8.
$\overline{\text{EOI}}$	End or Identify. IEEE Bus management line.
FM	Frequency Multiplier. Channel A conditioned input signal multiplied by 1000.
$\overline{\text{GQ}}$	Main Gate FF $\overline{\text{Q}}$ output.
$\overline{\text{GATE}}$	Gate indication to front panel LED display.
HOLD	Single or Continuous measurement selection.
$\overline{\text{IFC}}$	Interface Clear. IEEE Bus management line.
$\overline{\text{LISTEN}}$	IEEE Interface Listen status.
$\overline{\text{M}}$	Measurement Update.
MULT	Resolution Multiplier mode selected.
$\overline{\text{MULT}}$	Non-Resolution Multiplier mode selected.
$\overline{\text{NDAC}}$	Not Data Accepted.
$\overline{\text{NRFD}}$	Not Ready For Data
R, $\overline{\text{R}}$	Reset from Control Logic. Resets latches and accumulators.
$\overline{\text{R}}'$	Reset from Control Logic. Resets Channel B Squelch Latch.
$\overline{\text{REM}}$, $\overline{\text{REN}}$	Remote Enable.
RESET, $\overline{\text{RESET}}$	Front panel Reset.
$\overline{\text{RESETM}}$	Channel A Frequency Multiplier Reset.
RFD	Ready For Data.
$\overline{\text{RNG1}}$, $\overline{\text{RNG2}}$	Resolution Range lines.
S1 through S9	Digit Strobe 1 through Digit Strobe 9.
SC	Single or Continuous measurement selection.
$\overline{\text{SRQ}}$	Service Request.
ST, START	Remote Reset.
$\overline{\text{TALK}}$	IEEE Interface Talk status.
$\overline{\text{TALKEN}}$	IEEE Interface Talk Enable.
UX	Display Annunciator.



7220A-1301

Figure 8-1. Interconnect Diagram



7220A-1601

Figure 8-2. A1 Main PCB Assembly

NOTES: UNLESS OTHERWISE SPECIFIED:

1. ALL RESISTORS ARE IN OHMS
   ALL CAPACITORS ARE IN MICROFARADS.

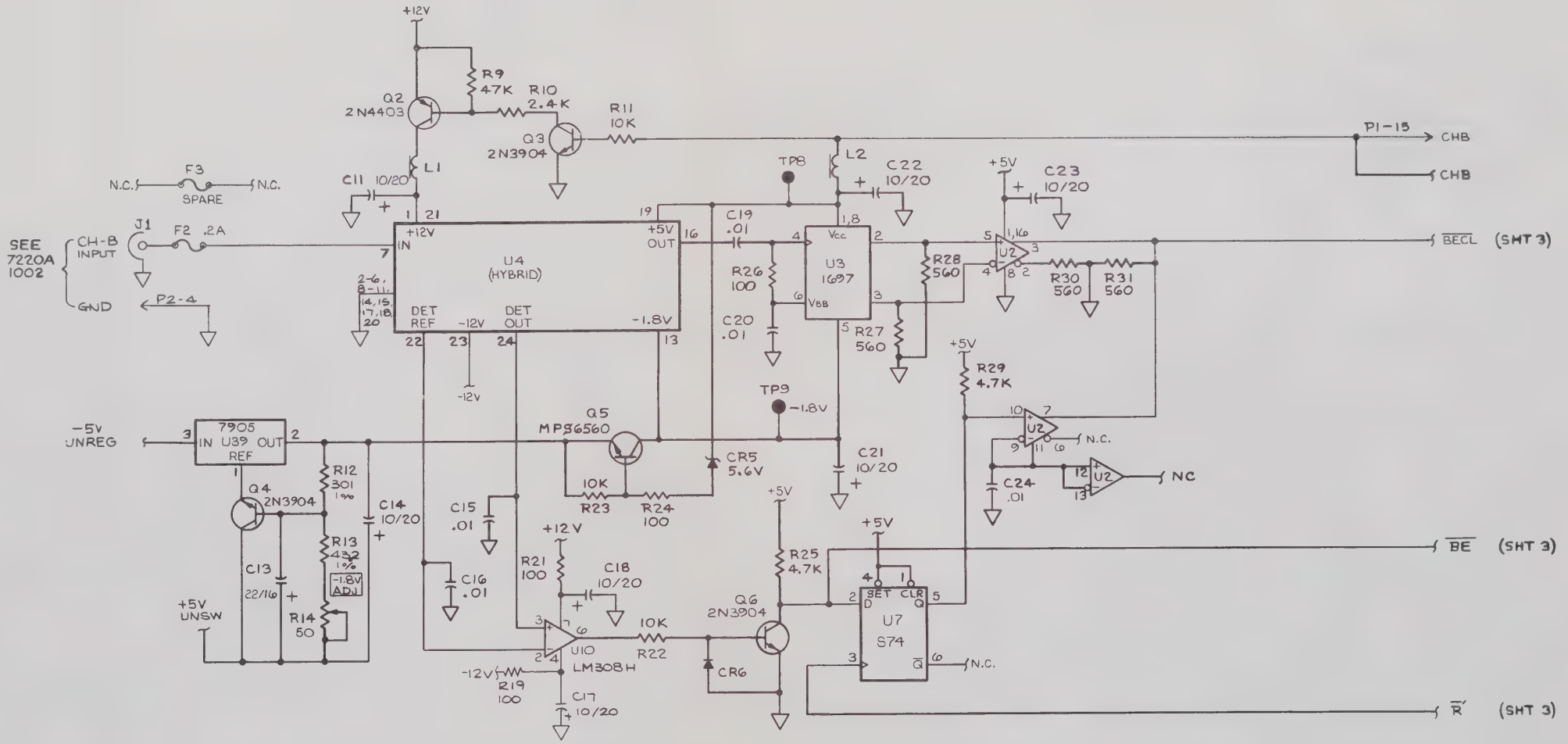
(SHT 4) MULT
P1-26
P6-5 ATTL
P6-6 MULT
RESET M
P6-7 RESET M
-12V
P6-2 -12V
P6-3 GND
P6-1 +12V UN-SW
SEE 7220A-1006

SEE 7220A-1010
GND JB1-3,5
JB1-9
JB1-7
UN-REG +5
JB1-10
-12V
JB1-2
UN-REG -12V
JB1-4
UN-REG +12V
JB1-6

AC IN
F1
E3
E1
E2
ON REAR PANEL
TC
T1
110/120
220/240
100/220
120/240
S4
S5
AC +
CR1
AC -
C1 470 uf 25V
C2 470uf 25V
U40 7812 IN OUT
U42 79L12 IN OUT
C5 10/20V
CR3
C6 10/20V
CR4
TP1 (+12V UNSW)
TP2 (-12V UN-SW)
S3
CR2
C3 470 uf 25V
C4 4700uf 16V
-5V UNREG
LM317 U41 IN OUT ADJ
C7 10/20V
C52 10/20V
R68 1K, 1%
R69 200
R70 3.01K 1%
5V ADJ
E7
E8
SB1
TP3 (+5V UNSW)
S1-B
C50
RESET
JB2-1 +5 RESET
JB2-2 BAT RESET
CHRG
+12V
+5V
-12V
ON
-5V UNREG JB1-1
S6
INT
EXT
TIMEBASE
+12V
SB4
SB3 +5V TCXO
SB5 +5V OVEN
S2
LINE
BAT
+5V
R8 27
C10 10/20V
+5V UNSW
C32-49 10uf/20V
JB2-7,8 GND
JB2-3 INVERT DRIVE
JB2-4,5 +5 BATT
SEE 7220A-1010
R1 1.8K
R2 180
R3 100
C9 .01
2N3906 Q1
R4 470
R5 4.7K
R6 470
C8 .01
TP4
SB2
OVEN (SHT 4)
10 MHZ (SHT 3)
REF IN
E4
E6
REF OUT
E5
R7 150
U27

7220A-1001
(1 OF 4)

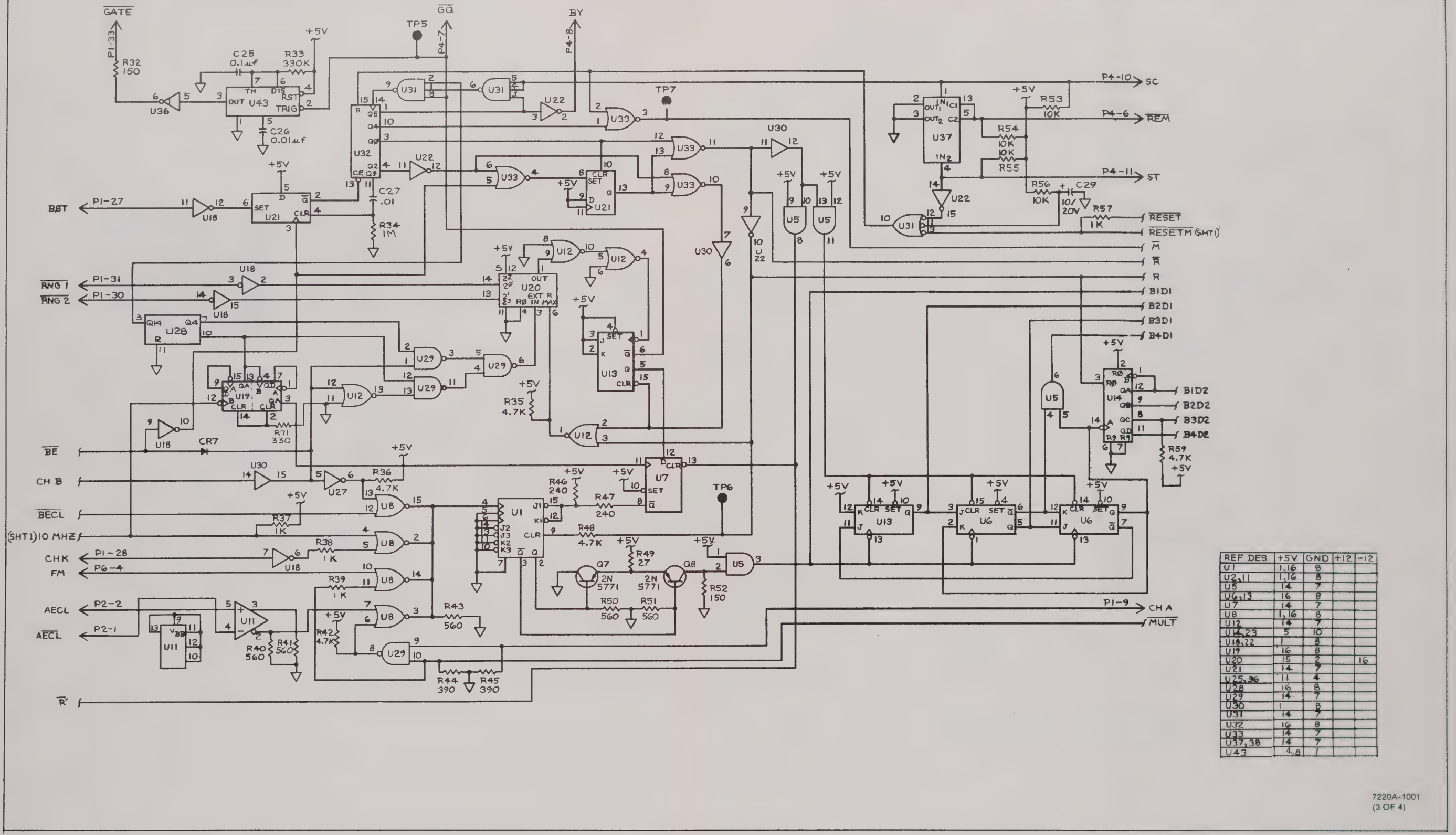
Figure 8-2. A1 Main PCB Assembly



REF DES	+5V	GND	+12	-12
U1	1,16	8		
U2,11	1,16	8		
U3	—	—		
U5	14	7		
U6,13	16	8		
U7	14	7		
U8	1,16	8		
U9	16	8		
U10	—	—		
U12	14	7		
U14,23	5	10		
U15	27	23		26
U16	16	8		
U17	16	8		
U18,22	1	8		
U19	16	8		
U20	15	2		16
U21	14	7		
U24	14	7		
U25,26	11	4		
U26	16	8		
U27	14	7		
U28	16	8		
U29	14	7		
U30	1	8		
U31	14	7		
U32	16	8		
U33	14	7		
U34,35	14	7		
U37,38	14	7		
U39				
U40		3		
U41		3		
U42		1		
U43	4,8	1		

7220A-1001
(2 OF 4)

Figure 8-2. A1 Main PCB Assembly (cont)



REF DES	+5V	GND	+12	-12
U1	1,16	8		
U2,11	1,16	8		
U5	14	7		
U6,13	16	8		
U7	14	7		
U8	1,16	8		
U12	14	7		
U14,23	5	10		
U18,22	1	8		
U19	16	8		
U20	15	2		16
U21	14	7		
U25,36	11	4		
U28	16	8		
U29	14	7		
U30	1	8		
U31	14	7		
U32	16	8		
U33	14	7		
U37,38	14	7		
U43	4,8	1		

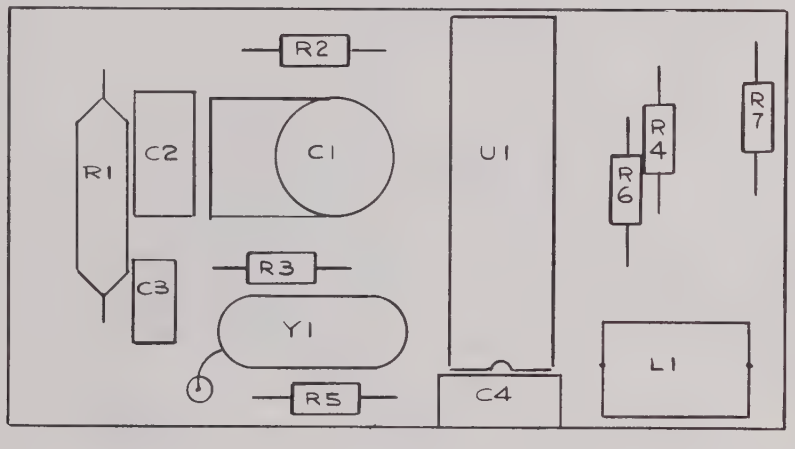
7220A-1001
(3 OF 4)

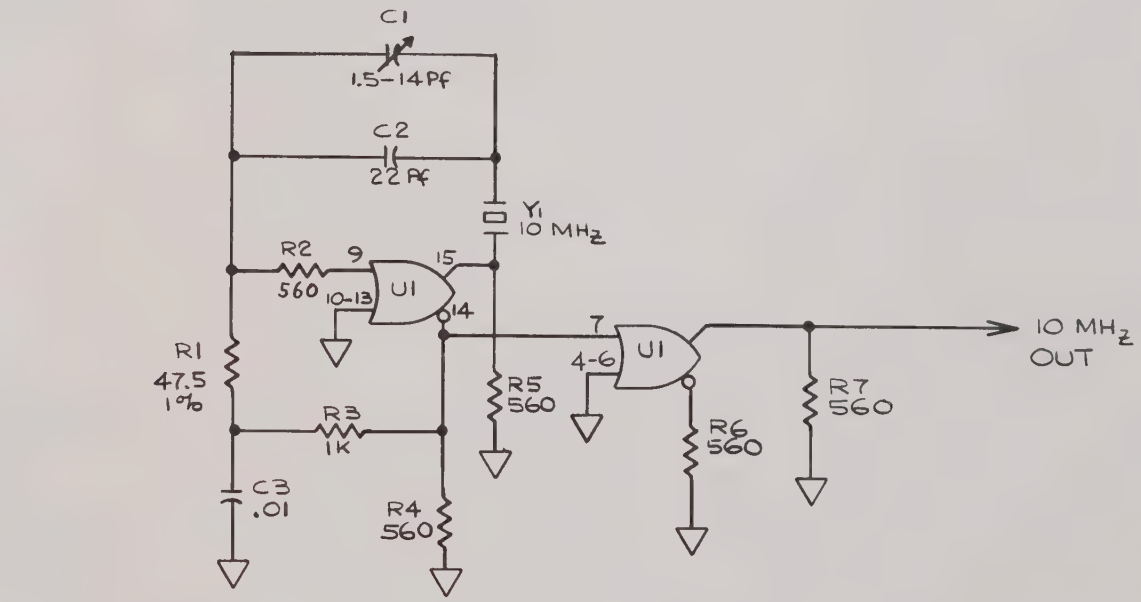
Figure 8-2. A1 Main PCB Assembly (cont)

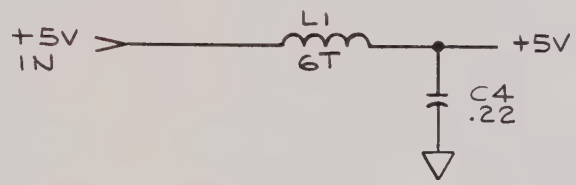
REF DES	+5V	GND	+12	-12
U9	16	8		
U14,23	5	10		
U15	27	23		26
U16	16	8		
U17	16	8		
U18,22	1	8		
U24	14	7		
U25,36	11	4		
U26	16	8		
U30	1	8		
U34,35	14	7		
U37,38	14	7		

7220A-1001
(4 OF 4)

Figure 8-2. A1 Main PCB Assembly (cont)







NOTES :

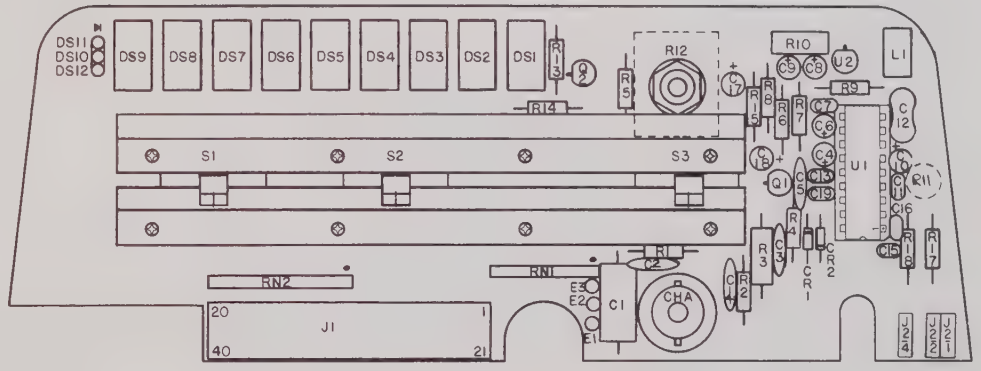
1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ARE IN OHMS, 1/8W.
   ALL CAPACITORS ARE IN MICROFARADS.

QTY	DEVICE	+5V	GND	REF DES
1	MC10109	1,16	8	U1

7220A-1609

7220A-1009

Figure 8-3. A3 Time Base PCB Assembly



7220A-1602

Figure 8-4. A2 Front PCB Assembly

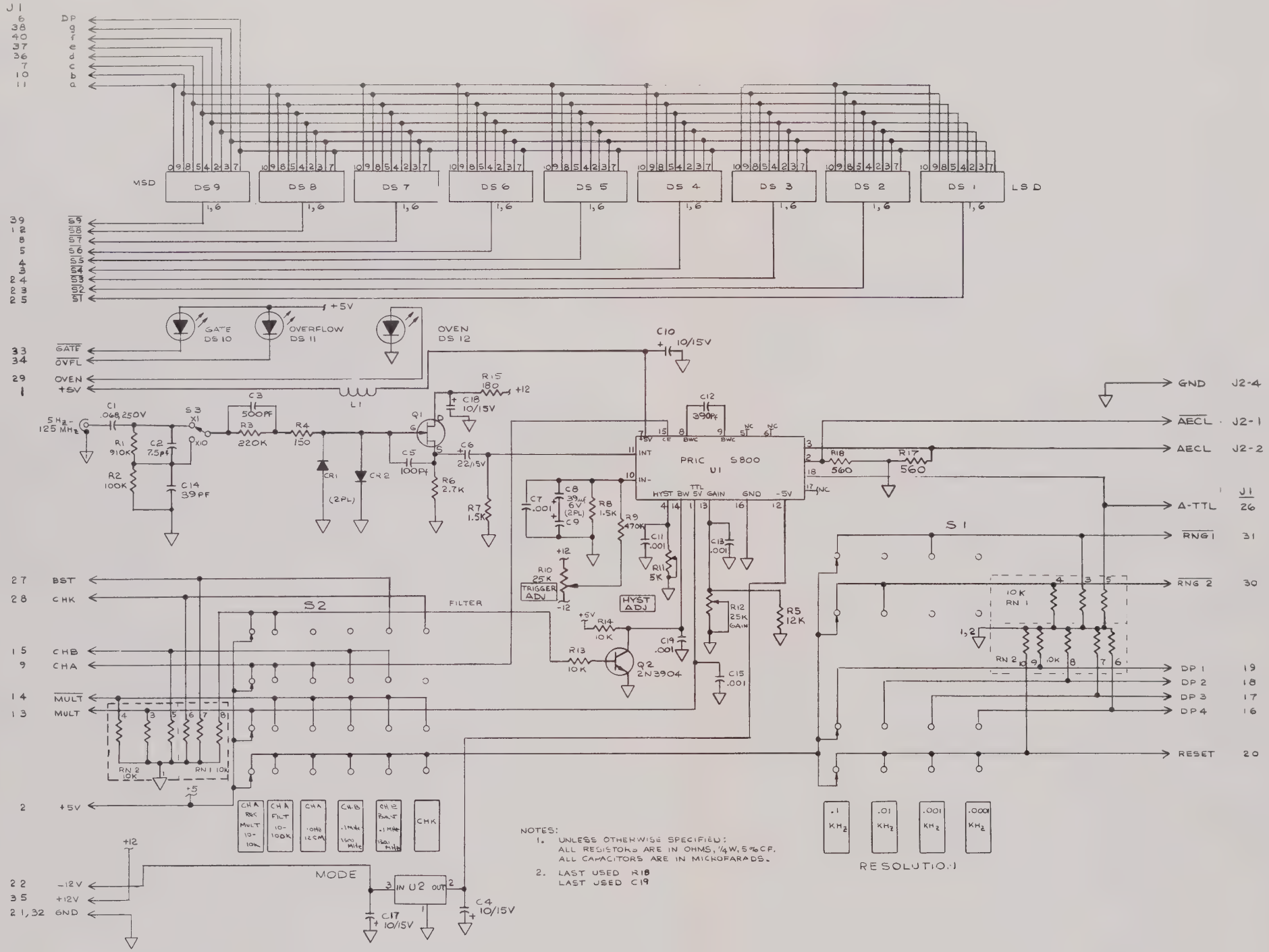
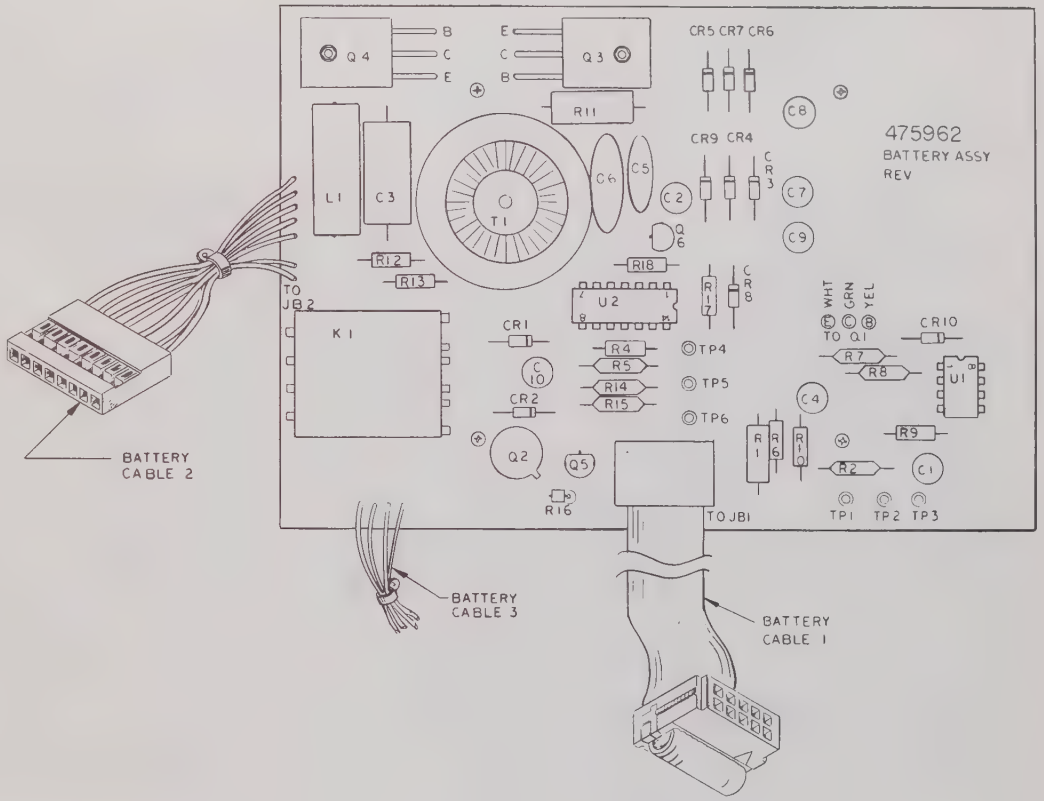


Figure 8-4. A2 Front PCB Assembly (cont)



7220A-1610

Figure 8-5. Battery PCB Assembly Option -010

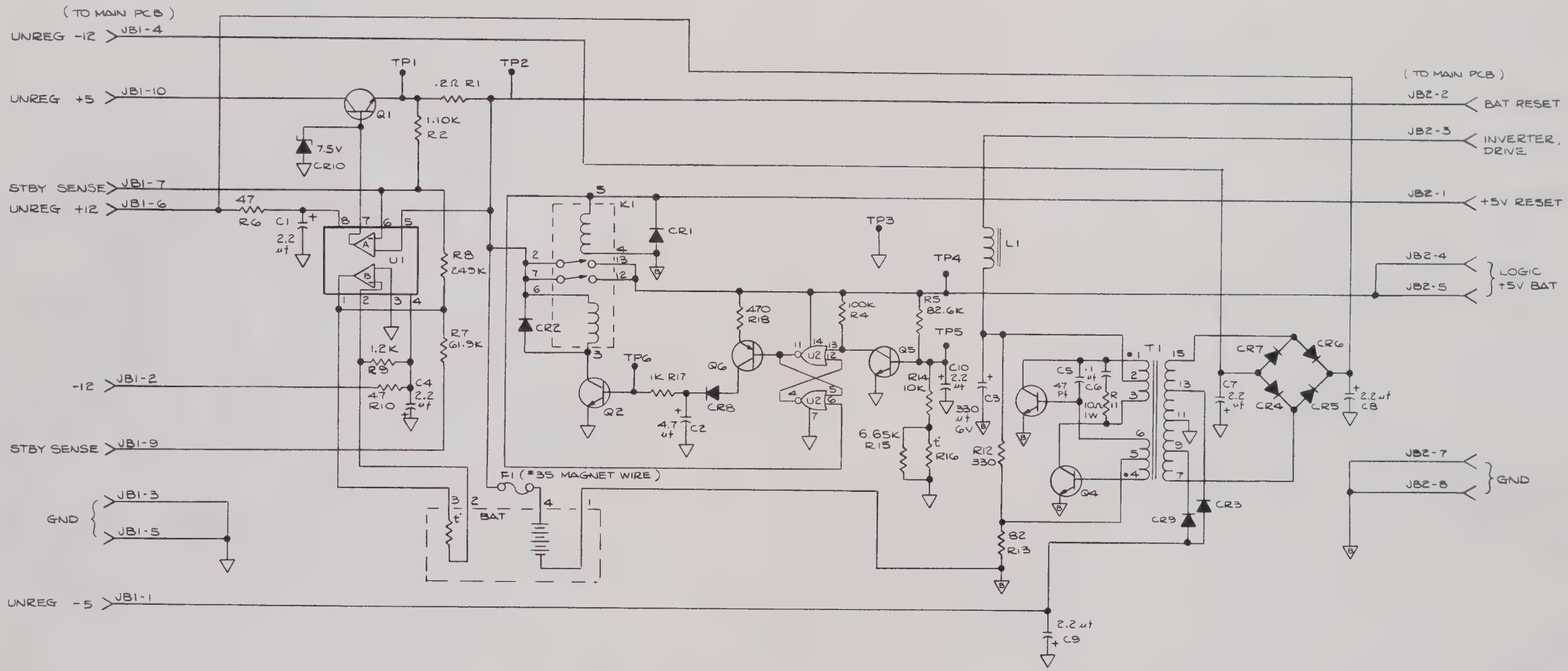
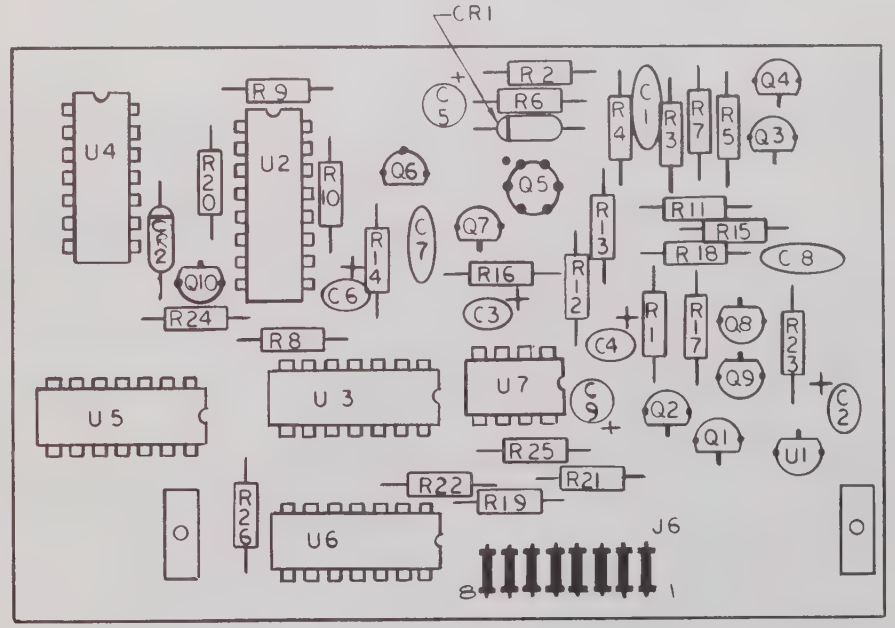


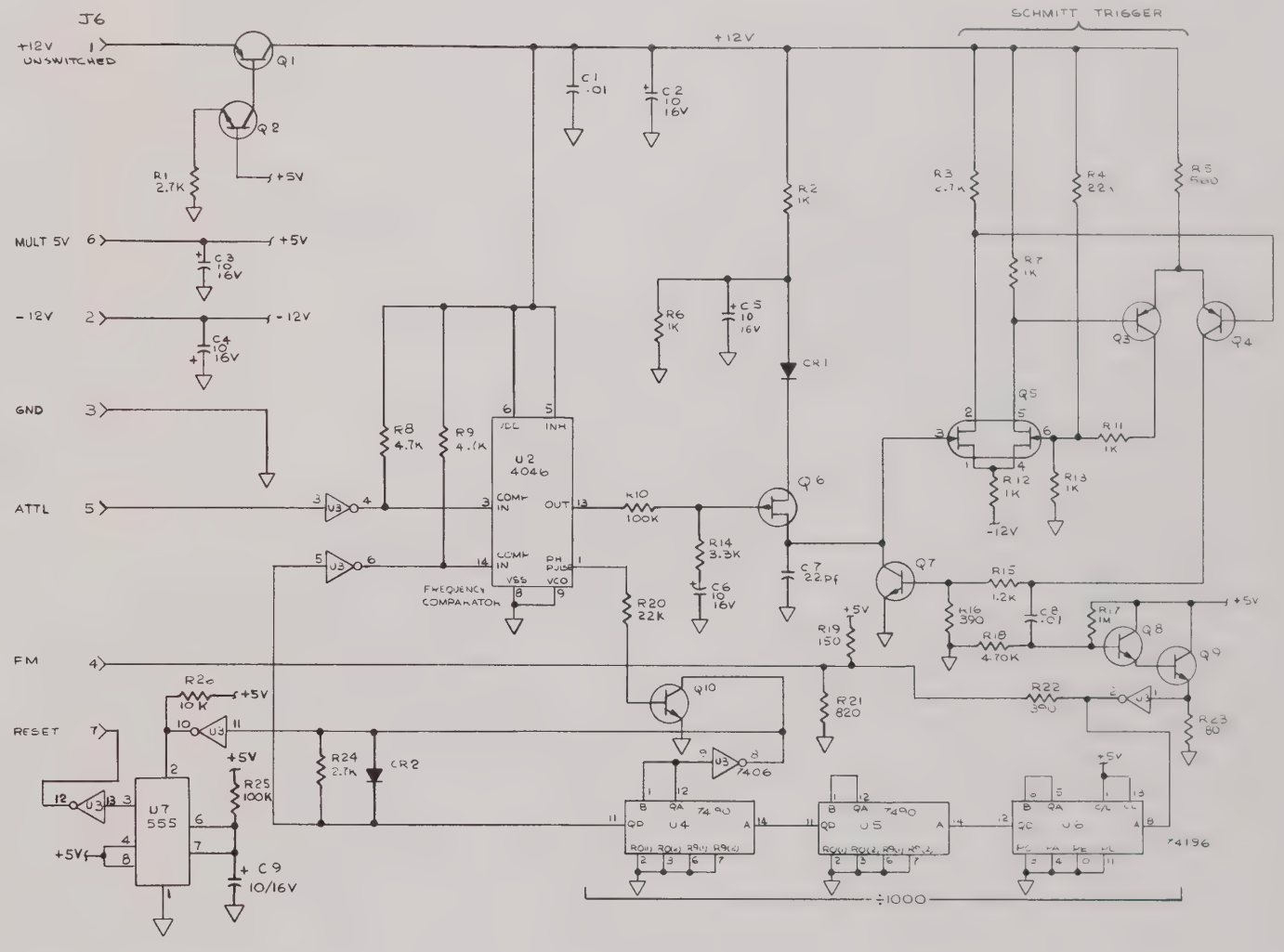
Figure 8-5. Battery PCB Assembly Option -010 (Cont.)



7220A-1606

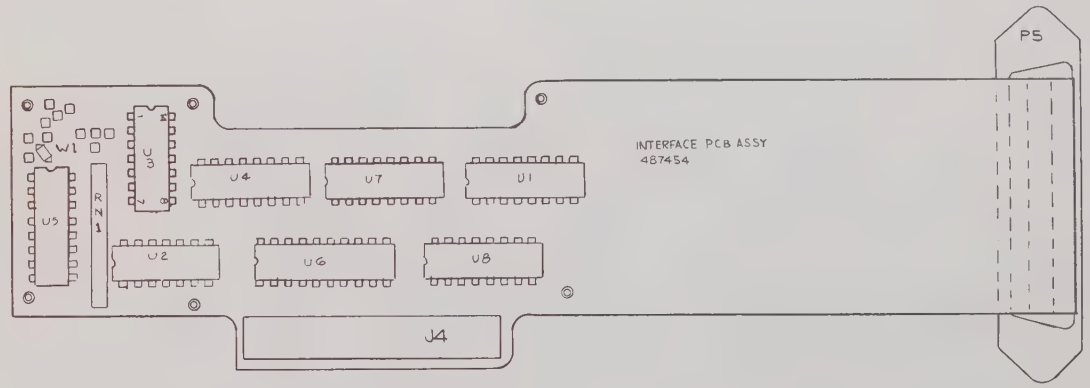
Figure 8-6. Resolution Multiplier PCB Assembly Option -351

NOTES:
1. UNLESS OTHERWISE SPECIFIED:
   ALL RESISTORS ARE IN OHMS, 1/4W, 5% CC.
   ALL CAPACITORS ARE IN MICROFARADS.



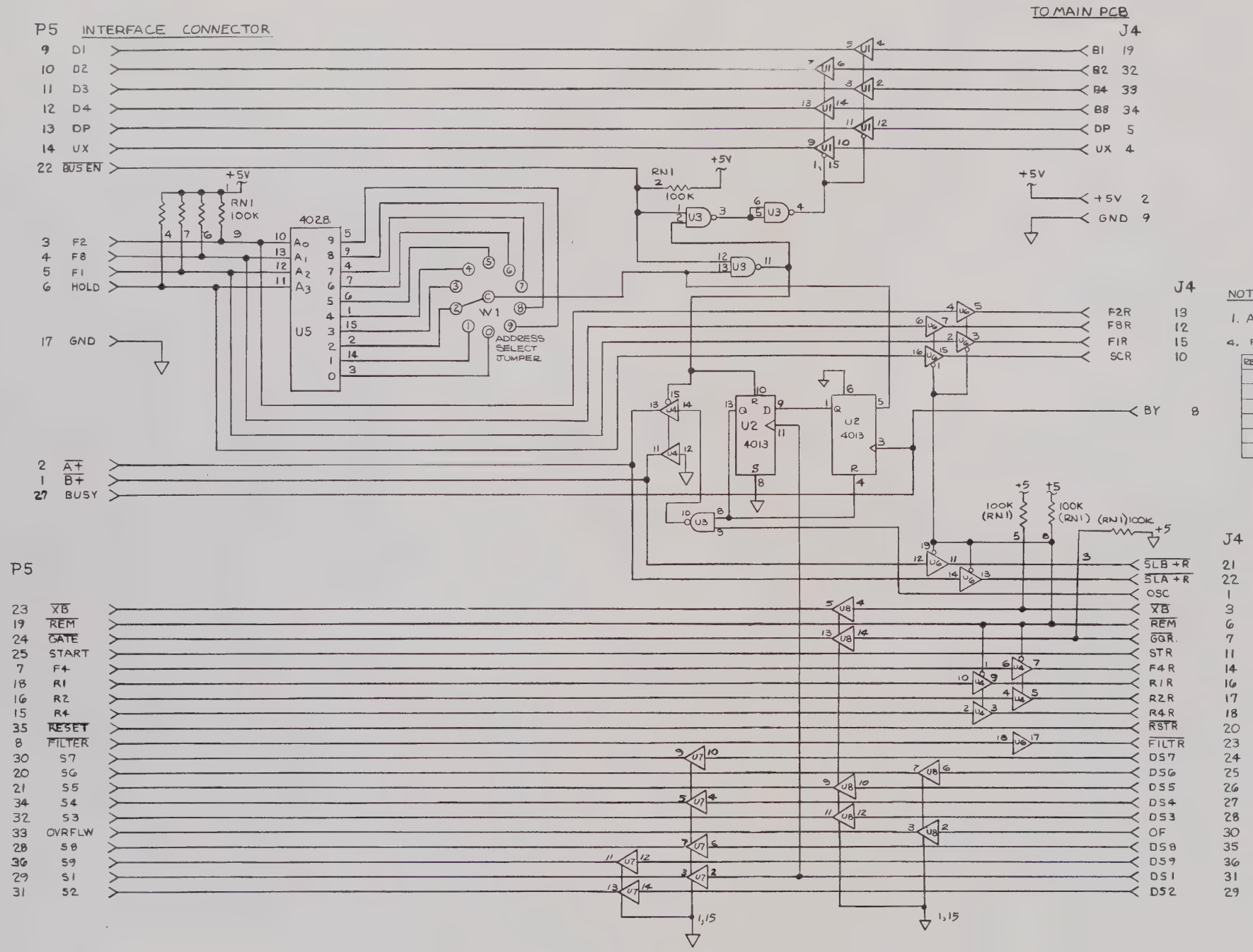
7220A-1006

Figure 8-6. Resolution Multiplier PCB Assembly Option -351 (Cont.)



7220A-1607

Figure 8-7. Digital Interface PCB Assembly Option -521



NOTES: UNLESS OTHERWISE SPECIFIED

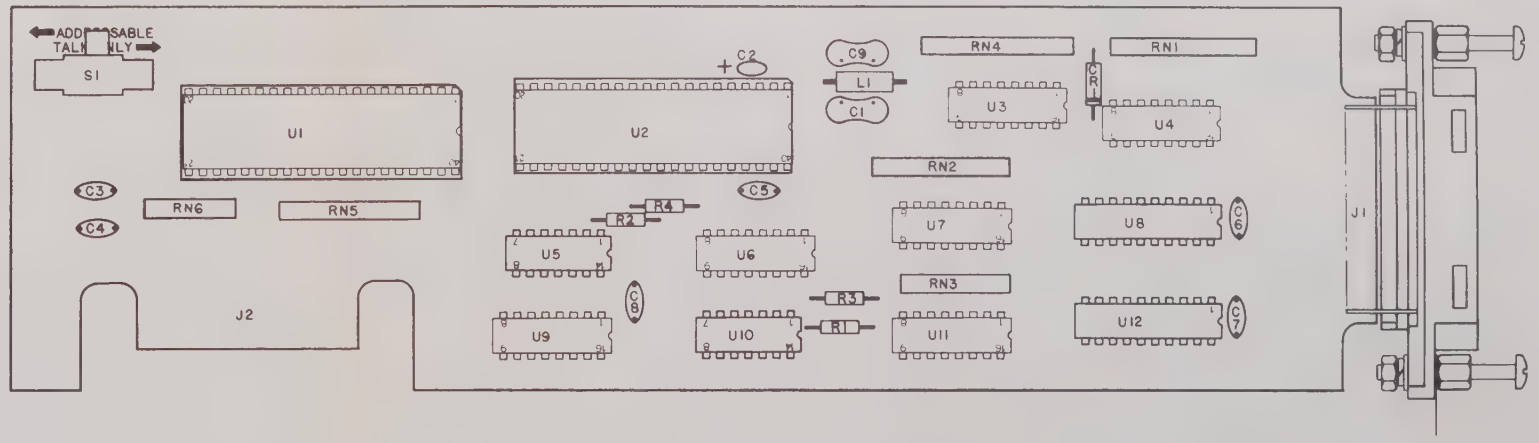
1. ALL RESISTORS ARE IN OHMS

4. POWER CONNECTIONS:

REF DES	TYPE (REF)	GND	+5V
U1	4009?	8	16
U2	4013	7, 8	5, 14
U3	4011	7	14
U4	74LS367	8	16
U5	4028	8	16
U6	81LS95	10, 8	20

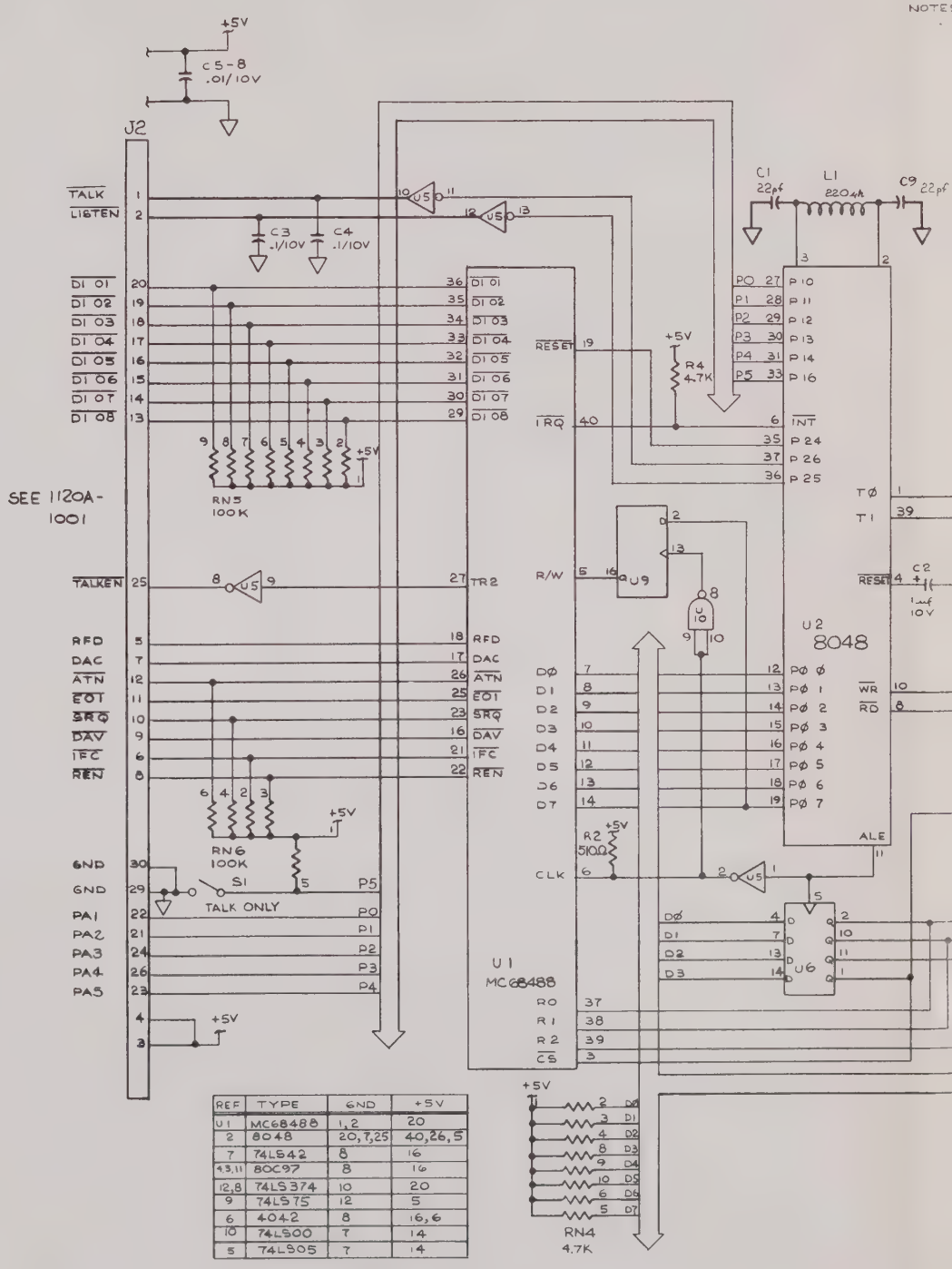
7220A-1007

Figure 8-7. Digital Interface PCB Assembly Option -521 (Cont.)



1120A-1604

Figure 8-8. Interface PCB Assembly Option -522



REF	TYPE	GND	+5V
U1	MC68488	1,2	20
2	8048	20, 7, 25	40, 26, 5
7	74LS42	8	16
4,3,11	80C97	8	16
12,8	74LS374	10	20
9	74LS75	12	5
6	4042	8	16, 6
10	74LS00	7	14
5	74LS05	7	14

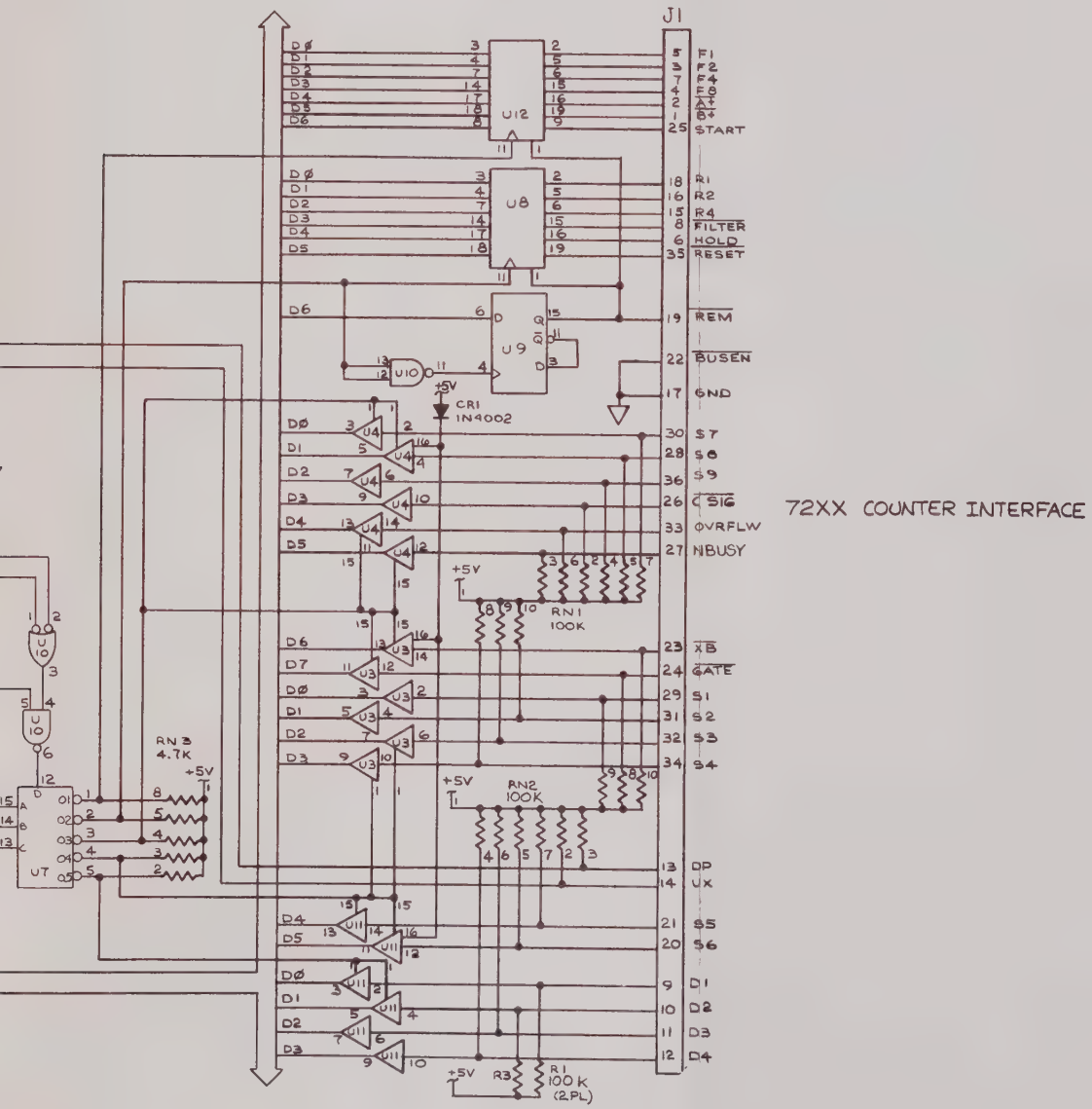


Figure 8-8. Interface PCB Assembly Option -522 (Cont.)

Application Bulletin

FLUKE®

AB-39

Practical Counter Applications

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Introduction

This application bulletin presents a few of the many applications possible with Fluke counters. The applications presented here are for the counters by themselves and in conjunction with other instruments. The general notes in Section 1 are intended as an aid to solving the difficult problem of measuring signals with super-imposed noise.

For more information about these applications or about other possible applications contact your nearest Fluke sales office or call the factory in Seattle at (206) 774-2481.

Section 1
Input Signal Processing

General Notes

All counters contain input signal conditioning circuitry whose function is to accept an analog signal of random shape and level, and convert it to a digital signal that can be measured by the counter. Trouble arises when noise and unwanted signals superimposed on the signal are large enough to be sensed by the input. The result can be false counting and readings that vary over a wide range in a random fashion.

There are many different kinds of noise: Ringing caused by unterminated cables, noise from ground loops, noise inherent in the signal source, and radiated noise or RFI. There are various mechanisms to prevent this noise affecting the counter.

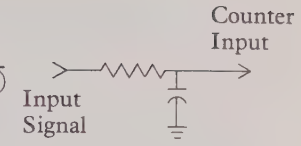
The counter operator can try shielding the cable and the counter to keep RFI out, terminating the cable at the counter to stop signal ringing, breaking grounds to prevent ground loops, filtering the signal to remove the noise, attenuate or reduce the signal level which will tend to reduce the amplitude of noise on the signal.

Attenuation is usually the easiest first choice as many counters have this feature built in, if not, external in-line attenuators, or pads, can be used. Attenuating the signal attenuates superimposed noise at the same time, reducing the noise to a point where the counter will not be affected by it. Filtering the signal is also an effective way to get rid of noise. If the counter does not have an internal filter, an external filter network may be made.

The following is an example that illustrates how to design a simple low pass filter to remove high frequency noise from a signal. (High frequency noise is one of the most common causes of false counting and unstable displays in counters.)

Example: You are measuring a frequency around 800 kHz, and would like to cut-off all frequencies above 1 MHz. Using the schematic in Figure 1 and assuming a 1K series resistor you can calculate the value for the capacitor using the following formula:

$$C = \frac{1}{2\pi fR}$$
$$= \frac{1}{(2)\ (3.14)\ (1x10^{6})\ (1x10^{3})}$$
$$= 1.59 \times 10^{-10}$$
$$= 159 \text{ pf}$$



You would select a capacitor as close to 159 pf ±10% as you can get. When you build the filter, be sure to keep the lead lengths short and the circuit lay-out well grounded, this will keep the noise from "leaking" around the filter.

By keeping the R value at 1K ohm, we can then come up with a handy table of cut-off frequencies in multiples of 1 MHz.

Table 1

f cut-off	R(ohms)	C
1 MHz	1000	159 pf
100 kHz	1000	1590 pf
10 kHz	1000	.0159 μf
1 kHz	1000	.159 μf

APPLICATION 1-1

Using A Voltmeter for Input Signal Processing

For low frequency measurements, a voltmeter with the proper output, and counter may be used together to extend the sensitivity range of the counter and to effectively float the counter input above or below ground.

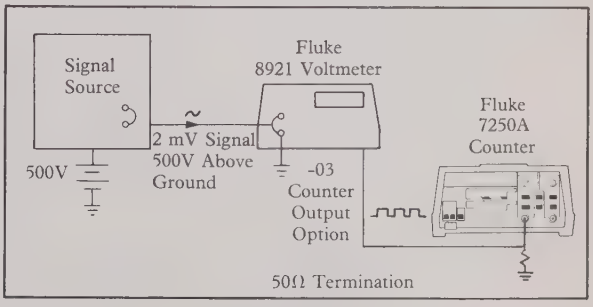


Figure 1

The Fluke 8921A in the example is a 20 MHz RF Voltmeter with a floating input. It can measure signals as small as 2 mV rms and elevated by as much as ±500V with respect to ground.

APPLICATION 1-2

Using A Scope for Input Signal Processing

An oscilloscope and a counter can be used together to make a superior measurement system. In this system the scope is used to condition the signal before it reaches the counter.

The scope can amplify, filter or attenuate the signal. Using a scope with a vertical signal out, the hookup would be as follows.

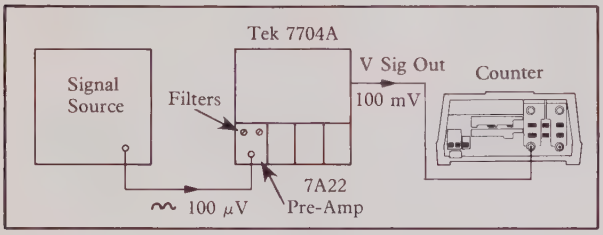


Figure 2.

In the above case, the 100 μV signal, which would normally be too small to be counted, is effectively amplified by the scope.

The 7A22 in the example has switch selectable low and high filters to further condition the signal if necessary.

APPLICATION 1-3

Floating Measurements of Computer Signals Using Battery Option

The battery option is very handy for testing large digital systems since it allows the counter to be connected directly into the circuit at any point without introducing power line ground currents. A X10 oscilloscope probe can be used to minimize capacitive loading in high speed circuits. Personal caution must be taken to avoid dangerous voltages while making floating measurements, as the external metal parts of the counter will assume those voltages.

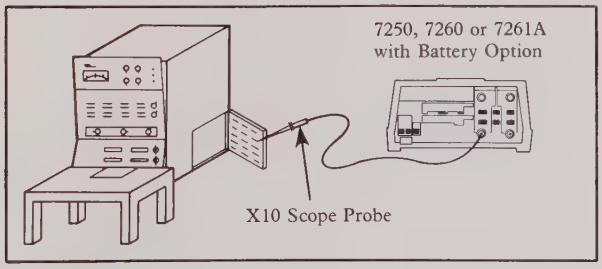


Figure 3.

Section 2
Measuring RF Transmitter Frequencies

Sample and Hold For Measuring CB Transmitter Frequencies

A CB carrier frequency may be measured without tieing up the channel for a lengthy period of time if the counter has a switch selectable external timebase input. See the counter to the frequency function and to the resolution desired. Key on the transmitter and adjust the distance between the antennas until a stable reading is obtained. Switch to the external timebase mode. The counter will immediately stop gating and *hold the reading* until you return the switch to the internal timebase mode. When using batteries with the antenna, we recommend a separate ground connection to prevent noise pickup. This is especially true when using the high impedance 1 MΩ input.

This may also be measured on the 7260A or 7261A by: slide the CONT/TRIG switch to the TRIG mode at the rear of the counter, with the B channel slope selector in the + position. Key the transmitter on and place it the same distance away from the counter, adjust the B trigger control slowly until the reading appears. It will now hold the display when the transmitter is keyed off.

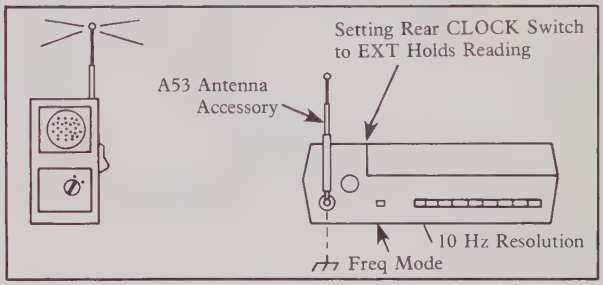


Figure 4.

Section 3
Period Measurements and Low Frequency High Resolution Measurements

APPLICATION 3-1

Using Period Average Mode for High Resolution at Low Frequency

For low frequency signals, the Period Average Mode offers higher resolution and faster display update rate than the frequency mode.

Example: Calibrate the line frequency of a portable power generator.

Using Frequency Mode the best resolution obtainable is 0.1 Hz (three digits) with a display update each 10 seconds. For Period Average Mode a calculator is used to calculate the precise period of 60 Hz. Period = 1/frequency = 16.66666 milliseconds. The generator is then adjusted until the counter display reads 16.66666 ms. Selecting Period Average Mode produces 7 digits of resolution in less than 1 second. Note that both resolution and update rate are substantially better than the frequency mode.

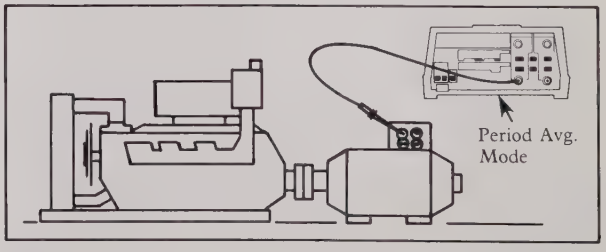


Figure 5.

APPLICATION 3-2

Heterodyne to Increase Resolution

In telecommunications it is common to calibrate signal sources to accuracies of $1x10^{-7}$ or $1x10^{-8}$. You can use a counter with a high stability timebase to do this. But what do you do when the desired accuracy is $1x10^{-10}$? There is a way to do this that will give you .1 MHz resolution and accuracies in the order of 10^{10} to 10^{11}. Consider the block diagram below.

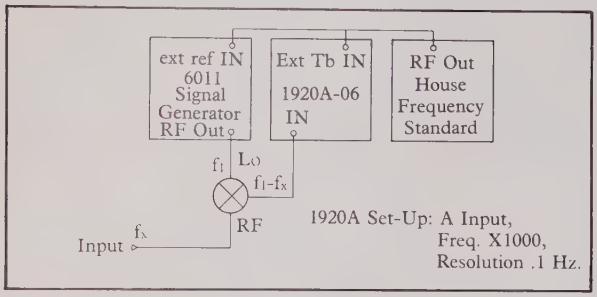


Figure 6.

We see a 6011A signal generator, a 1920A counter with option -06 (resolution multiplier) and, for best possible accuracy, couple both to a primary frequency standard to use as the measurement system timebase.

The principle of the measurement is to mix the input frequency with a reference frequency and then measure the difference frequency. To make sure that we always have a frequency difference, and not a frequency sum, at the mixer output, the reference frequency from the 6011A is set 1 kHz higher than the frequency we want to measure. Using a difference frequency of less than 10 kHz allows us to use the resolution multiplier in the 1920A. Besides giving high resolution in a relatively short gatetime, the resolution multiplier has a second advantage. Its limited bandwidth (10 kHz) attenuates both the sum frequency from the mixer output ($f_1 + f_x$) and much of the system noise. This means that a low pass filter, which is normally required at the mixer output, is not needed here.

If all of the instruments are coupled to the inhouse primary frequency standard, only its accuracy, the noise of the mixer and the accuracy of the resolution multiplier (±2 counts) affect measurement accuracy. When the mixer is used with a sufficiently low noise level (like a ZAD 1H from Minicircuits Labs) and the input signal levels are high enough, the noise of the mixer can be ignored. Total accuracy is less then: ±Accuracy of house standard ±2 Counts.

The limitations of the system are:
- frequency range of the mixer
- min/max input levels to the mixer
- mixer conversion loss
- sensitivity of the counter

Further, the signal levels input to the mixer should be equal to within a few dB.

An experimental system was built up with two 6011A Fluke Signal Generators (one for the known and one for the unknown signal), a 1920A-06, and ZAD 1H mixer with all instruments driven by a Fluke 1953A-10, high stability oven oscillator. The input signals to the mixer were varied between −20 dBm and +10 dBm at frequencies between one and 10 MHz. The error was always within the ±2 count limit. The mixer noise with this or any equivalent mixer is well below threshold and does not contribute to the total accuracy.

APPLICATION 3-3

Calibrating Function Generators Using Period Average

An inexpensive function generator can be calibrated during maintenance or after repair with good accuracy using the period average mode of a counter. Connect the generator to the counter and select the period mode on the counter and the desired resolution. The built in accuracy of the crystal time base will give lab calibration to the generator no matter what price range the function generator falls into.

The function generator can then be used to test other equipment in the repair or maintenance shop.

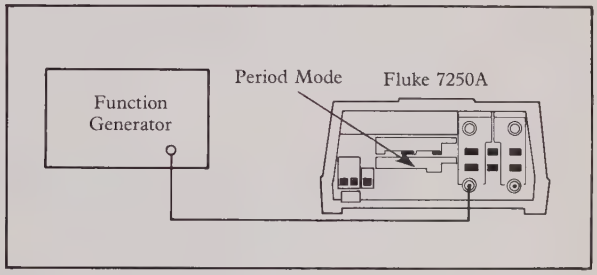


Figure 7.

Section 4
Totalize and A Gated By B Measurements

General Notes

Totalize is the simplest mode of a multifunction counter. In the totalize mode, the main gate is opened manually or by an external control signal. In this mode, the counter's time base is not used. Figure 8 shows the schematic in the totalize mode.

In the A gated by B mode, the A input is totalized during the time the B input is high. This is summarized in the diagram below, while the schematic for the A gated by B mode of the counter is shown in Figure 10.

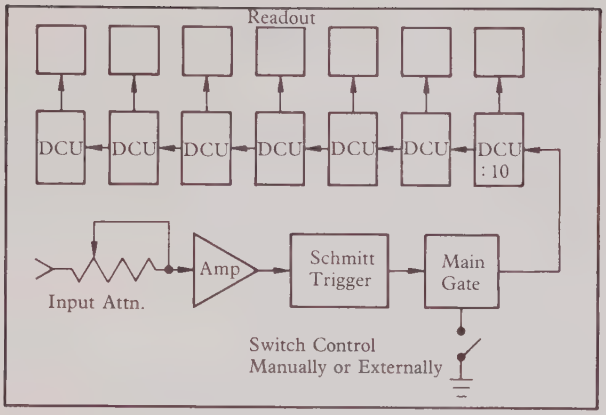


Figure 8. TOTALIZE MODE

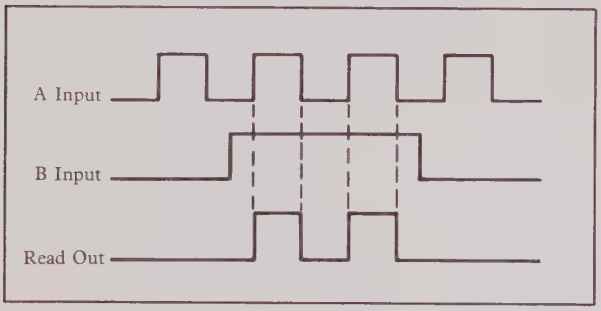


Figure 9. A GATED BY B READOUT

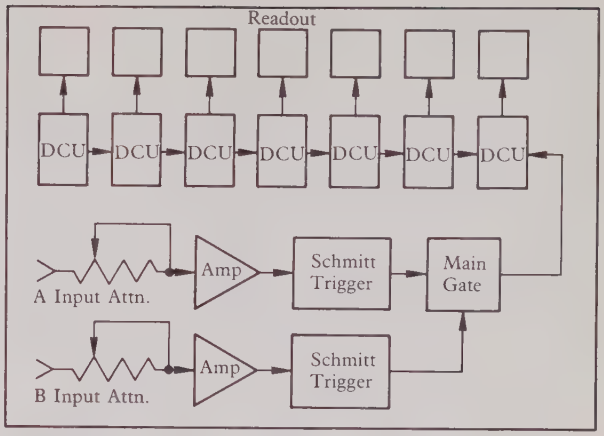


Figure 10. A GATED BY B

APPLICATION 4-1

Contact Bounce

When a relay or switch closes, its contacts will generally bounce a number of times due to the elasticity of materials used. Bouncing can be detected and the number of bounces counted, with the set-up in the diagram below.

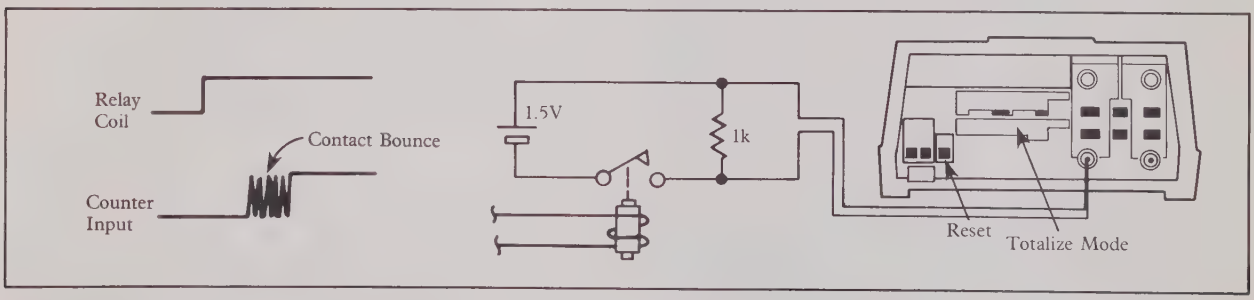


Figure 11.

When the relay (or switch) is closed, each contact bounce will be totalized on the counter.

APPLICATION 4-2

Counting the Number of Pulses in a Burst

When counting the number of pulses in a burst where the signal amplitude is very small or the modulating waveform is not available to trigger the counter, the set-up in Figure 12 is useful.

In this example, the oscilloscope vertical amplifier amplifies the signal amplitude and the B Gate Out signal provides a signal that can be used to control the measurement time of the 1953A in its A gated by B mode.

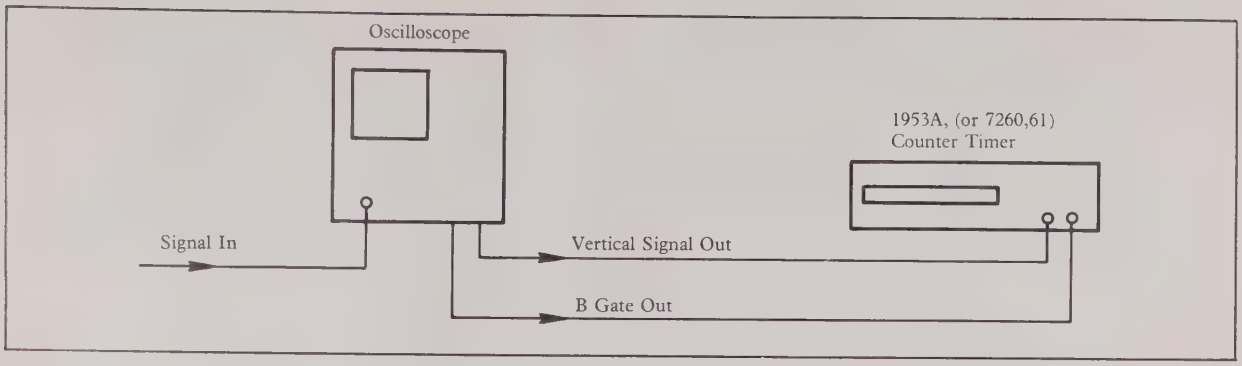


Figure 12.

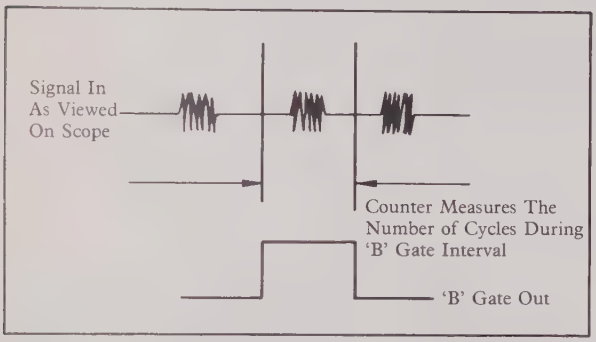


Figure 13.

On an oscilloscope with delayed sweep, the position and duration of the "B Gate Out" pulse may be adjusted by the delayed sweep controls. To make this measurement, the delayed sweep controls are adjusted so that the intensified portion of the sweep exactly brackets one signal burst. In the example in Figure 13, The 1953A, in the 'A gated by B' mode, will totalize the number of cycles in the signal burst over the duration of the 'B gate out' pulse. If the bursts are repetitive and requirement is to totalize the number of pulses in a single burst, set the oscilloscope trigger mode switch to "single sweep". The scope will then put out a single B Gate Out cycle and the 1953A will totalize pulses in only a single burst.

APPLICATION 4-3

Elapsed Time Using Clock Out of 1925A or 1953A

Elapsed time may be measured using the above diagram, with the counter in the totalize mode. At the start of the event the switch is closed by the operator. The counter, which as a 10 MHz timebase, will give a display of 10 000 000 in one second of time, or 1.000 000 seconds. This is 10 ns resolution! If 12 seconds go by, your display will be 10 000 000 x 12 = 120 000 000, and if 60 seconds go by, your display will be 60 x 10 000 000 or 600 000 000.

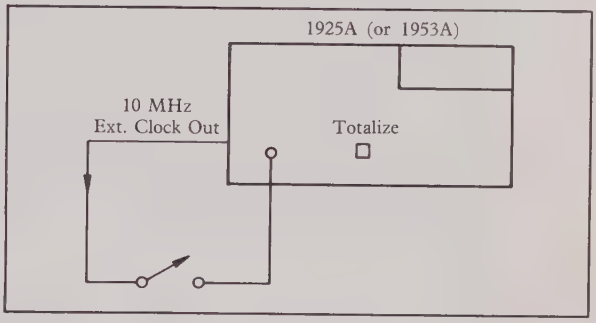


Figure 14.

If you wish to totalize electronically you may use a NAND gate connected in the diagram below.

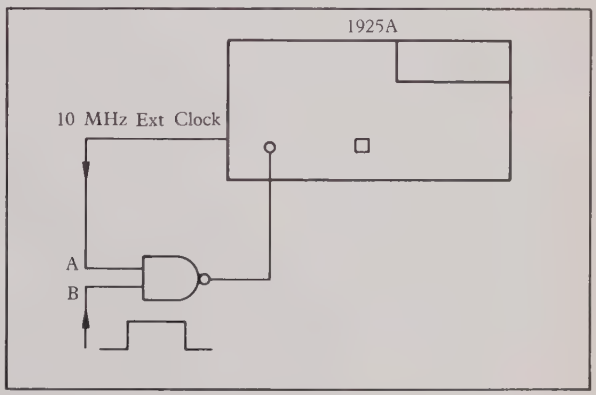


Figure 15.

APPLICATION 4-4

Elapsed Time Using Totalize

While the 10 ns resolution of application 4-3 is outstanding, it can be too much for some measurements. The solution to this is to reduce the frequency counted.

With an input frequency of 1 kHz, each pulse totalized represents an elapsed time of 1 millisecond. To read minutes, change input frequency to 1.6667 kHz, the display will read in milliminutes. These lower frequencies will fill the display more slowly.

If your only signal source is an inexpensive function generator, it should be set to frequency using the counter in its frequency mode.

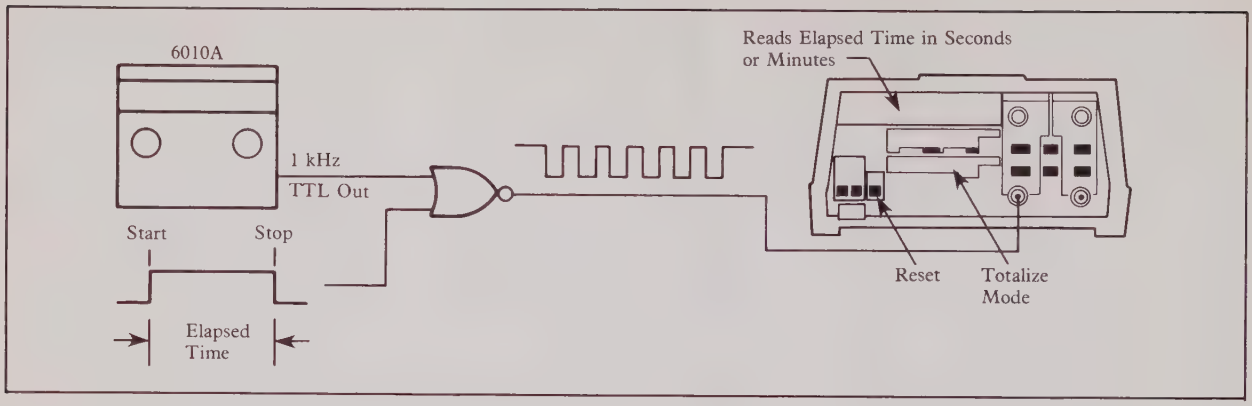


Figure 16. ELAPSED TIME USING TOTALIZE MODE

Section 5
Time Interval Measurements

General Notes

The time interval function is used to measure the time between two selected points on a waveform or the time between selected points on two separate waveforms. Time interval measurements require two separate input channels with separate circuitry for triggering levels, polarity and slope. Refer to Figure 17.

The main gate is opened by input A and closed by input B. During the time the main gate is open, the counter is counting its own internal oscillator.

The time interval mode is a most versatile and useful counter mode but it is not available on all counters because of the additional circuitry that is required is costly. Usually counters that offer time interval are referred to as Universal Counter Timers.

Some applications for time interval measurements include: delayed sweep calibration of scopes, digital circuit evaluation, and cable length measurements by pulse propagation time measurements.

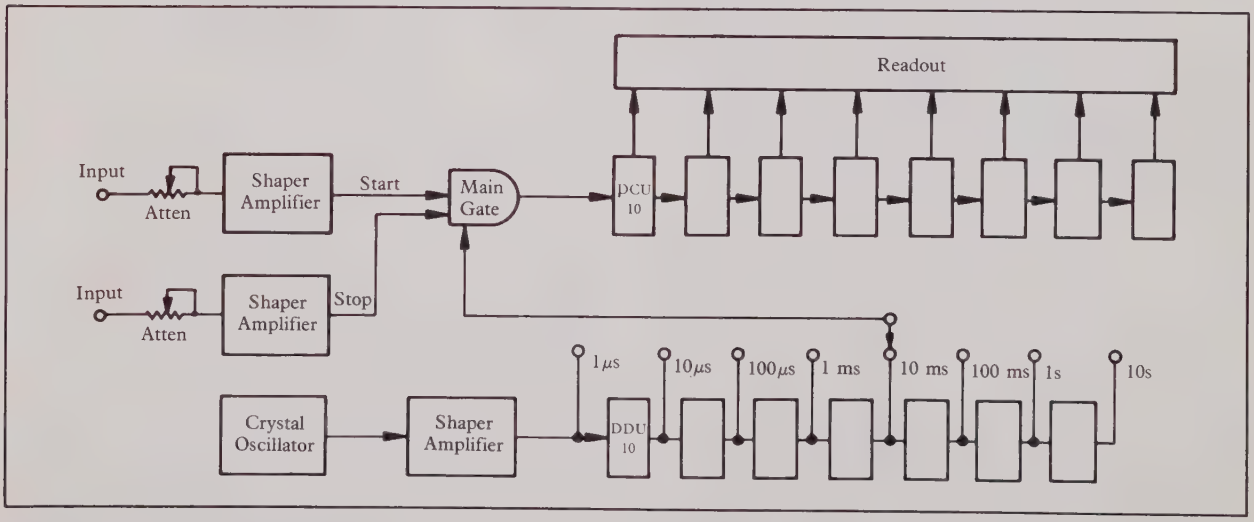


Figure 17. TIME INTERVAL

APPLICATION 5-1

Time Interval Using Scope B Gate

A delayed sweep oscilloscope and a 7250A Universal Counter Timer can be used together to measure the time duration of various parts of complex signals. The intensified portion of the trace is exactly positioned over

the signal to be measured. The time interval of the oscilloscope's "B Gate Out" as measured on the 7250A, will then equal the duration of the complex signal.

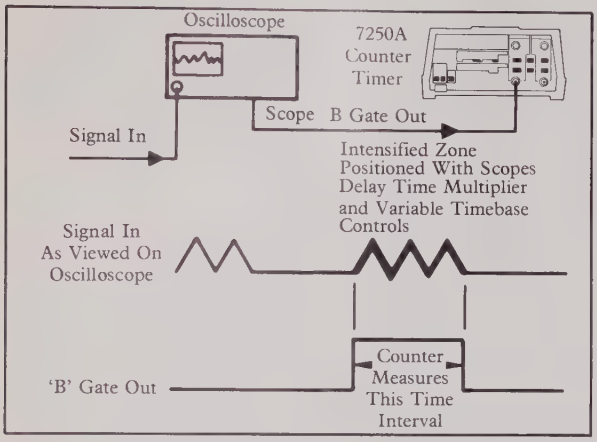


Figure 18.

APPLICATION 5-2

Time Delay Measurements with Scope Time Delay Multiplier

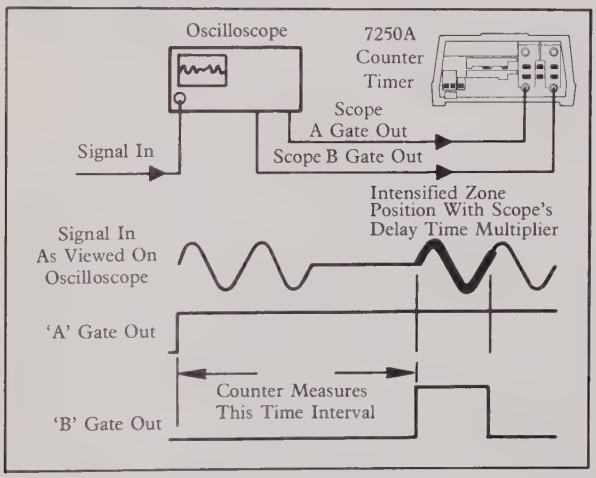


Figure 19.

The above diagram illustrates a technique to measure precisely the time from the beginning of an oscilloscope sweep time to any other point on the sweep. The technique requires an oscilloscope with "A Gate Out" and "B Gate Out" as well as delayed sweep. The counter, a Fluke 7250A, has 100 s resolution in the time interval mode.

APPLICATION 5-3

Using the Marker Output

To enhance trigger level setting accuracy for time interval measurements, use the marker output of the 7260A in conjunction with a dual trace oscilloscope. As the diagram shows, the signal displayed on the oscilloscope will represent the time interval being measured by the 7260A. You may change the trigger points by varying the trigger controls on the counter.

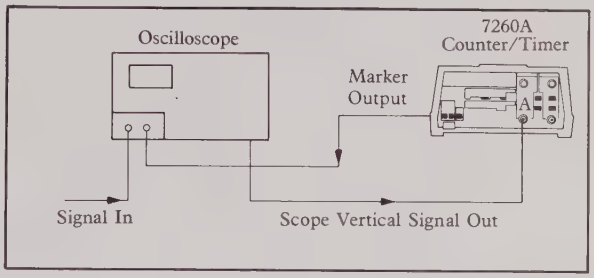


Figure 20. INTERCONNECTIONS FOR MARKER USE

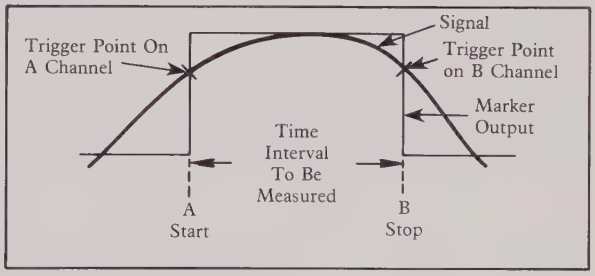


Figure 21. MARKER & SIGNAL

APPLICATION 5-4

Time Interval Using Dual Trace Scope In "Add" Position

A universal counter, when combined with a dual trace, delayed sweep oscilloscope, can precisely measure the period, width, or time interval between non-adjacent pulses of any waveform. An oscilloscope alone can perform these measurements, of course, but not with the accuracy of a counter. On the other hand, the counter input is "blind" and does not know which region of the waveform to measure. Uniting both instruments makes a superior measurement system.

For a scope to measure the period, width, or time interval between two given points of a specific waveform, the scope must isolate the interval of interest and so provide the gating necessary for counting. Thus a scope with a delayed sweep option is required.

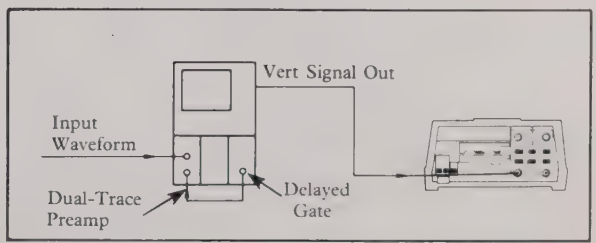


Figure 22.

Counter/Scope used to perform more types of measurements, more accurately, on waveforms than either instrument alone.

As shown in Figure 22 the delayed-gate output of the scope (whose pulse width and position are identical to the portion of the input waveform that's intensified) is connected to one of the vertical input channels and the waveform to be measured to the other. The scope is then placed in the input channels algebraic-add mode. With the scope's horizontal-mode switch in the intensified position, the portion of the waveform of interest is then selected with the delay-time multiplier control. The section of input waveform that the user has chosen to intensify will be elevated above ground potential (Figure 23). It is then a simple matter to adjust the counter's threshold control to trigger at a selected point on the elevated section of the waveform appearing at the scope's vertical signal output port.

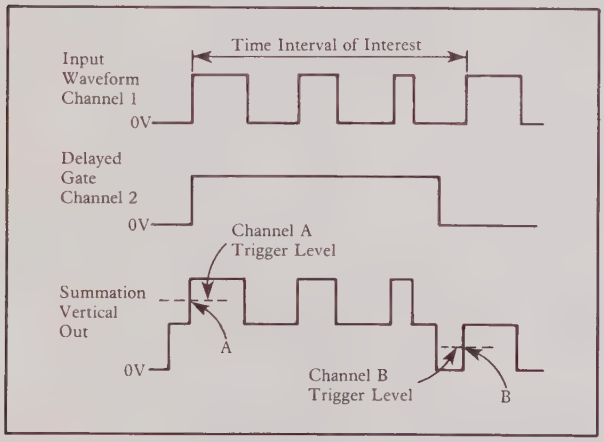


Figure 23.

Section 6
Ratio Measurements

General Notes

The ratio function is used to measure the frequency ratio of two input signals. One signal is coupled into Channel A, the other into Channel B, as in the diagram below.

Assume that the counter must measure the time between points A and B as shown in the above diagram. Place the counter in its time interval mode, and make sure that channel B of the counter will not trigger until channel A has done so. The threshold of each channel is set so that the rising edge of the elevated waveform triggers channel A of the counter, and channel B triggers after the elevated pulse has returned to its normal level. Thus the middle region of pulses contained in the elevated waveform will then be ignored by the counter.

APPLICATION 5-5

Time Interval Hold-Off

If you wish to measure the time of a contact from close to open, this may be made using a 7260A or 7261A counter. Without time interval hold-off, the time interval between A to B in the above diagram, would be measured. With T.I. hold-off, the initial bouncing can be ignored, and the time from A to D, or close to open, can then be measured.

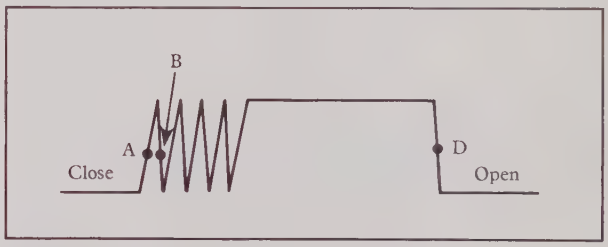


Figure 24.

Usually the higher frequency will be applied to the A input and the lower frequency to the B input. Ratio measurements are accomplished by using B input to open and close the main gate, and counting the A input. Example: if the two input frequencies were 1 MHz and 1 kHz, 1 kHz would be connected to the B input and the 1 MHz signal to the A input. The main gate would then be gated on for $\frac{1}{1000}$s or 1 ms, during which 1000 pulses

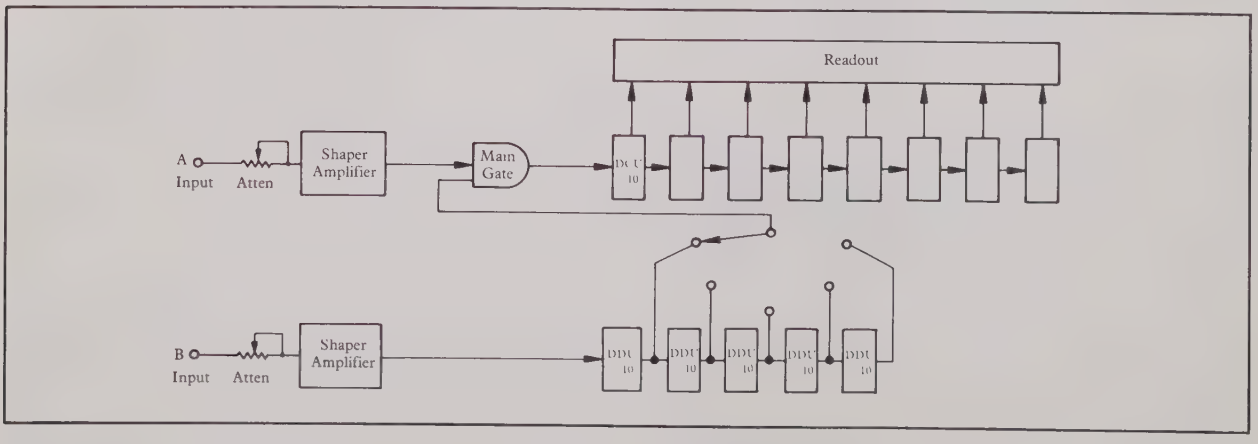


Figure 25. RATIO MODE

of 1 MHz would pass through the main gate. The readout would display 1000, which would indicate a ratio of 1000 to 1.

APPLICATION 6-1

Ratio Mode for Checking ÷ N Dividers

Checking the frequency dividing function of programmable dividers (like the one in the phase locked loop circuit of Figure 25) is an easy job for the ratio function. To test the divider ratio, connect the divider-in signal to the A input of the counter and the divider-out signal to the B input of the counter. After selecting the ratio function the counter will then display the ratio of the two frequency. This will equal the actual division ratio.

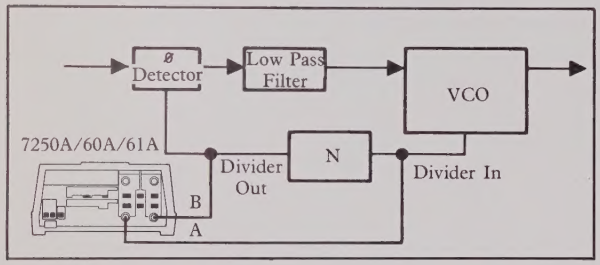


Figure 26.

APPLICATION 6-2

Frequency Ratio Using Ext Clock Input

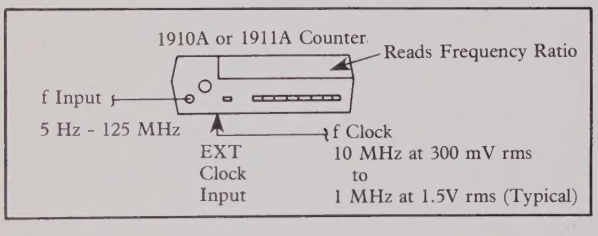

1910A or 1911A Counter
Reads Frequency Ratio
f Input
5 Hz - 125 MHz
f Clock
EXT Clock Input
10 MHz at 300 mV rms to 1 MHz at 1.5V rms (Typical)

Figure 27.

If your counter does not have a ratio function, the external clock input may be used to implement ratio. Put the input nearest to 10 MHz in the clock input and the other signal in at the front panel. Select the frequency function and read the display. The relationship between the two frequencies and the display is:

$$\text{Display} = \frac{\text{f input} \bullet 10\ \text{MHz}}{\text{f clock}}$$

Examples: 60

f input	f clock	Display	
60.0 Hz	1.0 MHz	.06000 kHz	.01 Hz
111.1 Hz	888.88 kHz	1.250 kHz	resolution!
2.2 MHz	7.0 MHz	3.1429 MHz	
123.45 kHz	6.54321 MHz	188.669 kHz	

Ratio mode is often used to provide greater resolution than normally available in the frequency mode. In the first example the 1.0 MHz external clock expands the maximum gate time to 100 seconds providing .01 Hz resolution.

There are a few things to keep in mind with this application:

1) The external clock has only limited bandwidth, perhaps 10 MHz ± 1 MHz. For our example the clock input is 10 MHz ± 1 MHz and − 9 MHz.
2) The external clock input usually needs TTL levels to work properly and keep measurement errors for a minimum.

Section 7
Industrial Applications

APPLICATION 7-1

Measuring RPM

Use the direct input and select FREQ mode with 1 Hz resolution (1 second gate time). 60 pulses per revolution will make the counter read directly in RPM with correct decimal. The 60 tooth wheel and transducer combination can be purchased from Dynapar Corp., Gurnee, IL 60031. NOTE: Magnetic transducer pulses are sometimes noisy. Use the Attenuator and Trigger Level Control to minimize this problem, and if necessary use a low-pass filter such as the Y7201 on the 1 KHz range.

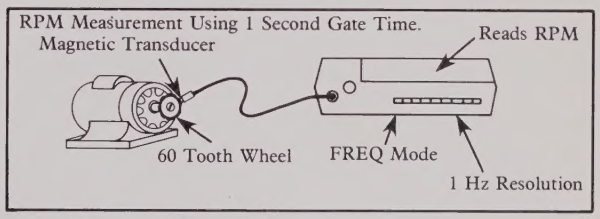


Figure 28.

APPLICATION 7-2

Scaled Readout Using Variable Ext Clock Input

Using a variable timebase for the EXT CLOCK input, the counter display can be made to read out directly in industrial units of feet/min, gallons/hrs, etc. In the below example, the counter is providing a direct readout of surface velocity of the conveyor belt. *The external clock frequency is calculated as follows:*

$$\text{Velocity} = V = 2\pi r \bullet \text{rpm} \quad \text{(feet/min)(2)}$$

where r = drive pulley radius in feet

$$\text{f input} = \frac{\text{rpm}}{60} \bullet N\ \text{(Hz)} \qquad (3)$$

If we let Display = Velocity and substitute equations (2) and (3) into equation (1) from Application Note 6-3 (1), the result is:

$$\text{f clock} \qquad \frac{N}{120\pi r}\ \text{(MHZ)} \qquad (4)$$

Example:

N = 100, rpm = 60, r = 1 ft

Velocity = (2π) (1) (60)

= 376.99 ft/min

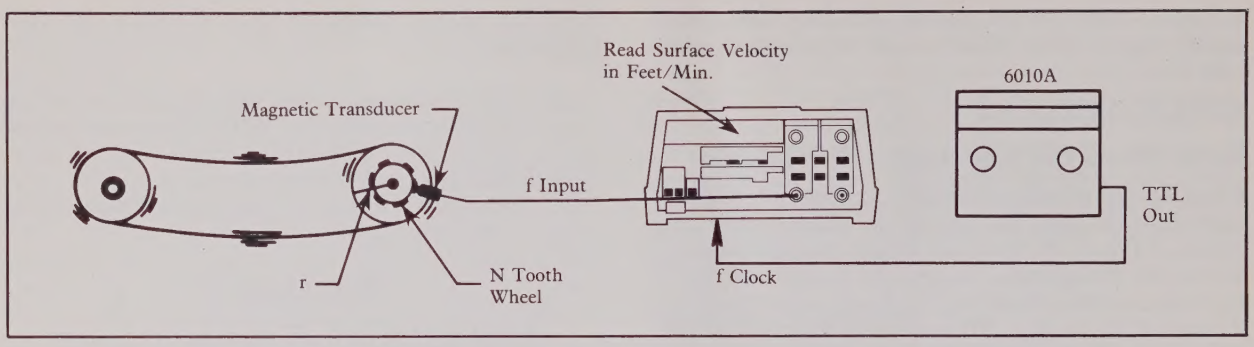


Figure 29.

The counter will read .377 kHz (kilo feet/min) if the external clock frequency is 2.65257 MHz. This frequency is calculated using equation (4) as follows:

$$f\ clock = \frac{(100)}{(12)\ (3.1416)\ (1)}\ MHz$$

$$= 2.65257\ MHz$$

APPLICATION 7-3

Measuring Frequency Using 80I-600 Current Probe

The clamp on probe is a good way to measure frequencies on a large voltage signal. This method not only isolates the counter from the high voltage but also attenuates noise commonly found on high voltage signals. Connect as in the diagram below with a resistor to give an input voltage to the counter within its sensitivity range. You can then read out the frequency on the counter.

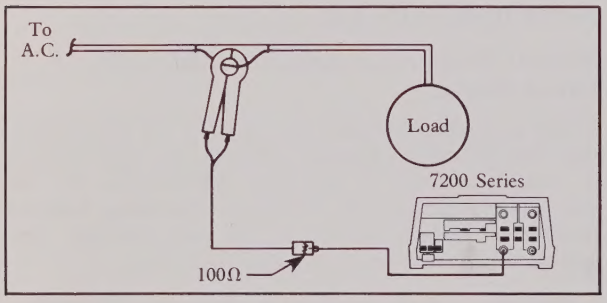


Figure 30.

APPLICATION 7-4
Measuring RPM With 7250/60/61A

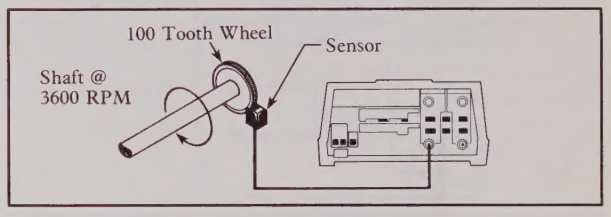


Figure 31.

RPM measurements can be made on a 100 tooth wheel easily using a 7250, 60, or 61A counter.

If a shaft is turning at 3600 RPM, as in the diagram above, with a 100 tooth wheel, the sensor output is 360,000 pulses/min. Dividing this by 60 to get pulses/sec = 6000 pulses/sec.

You may prove the counter reading by feeding in 6 kHz and then place the function slider in the CPM mode — the counter will read 3600.

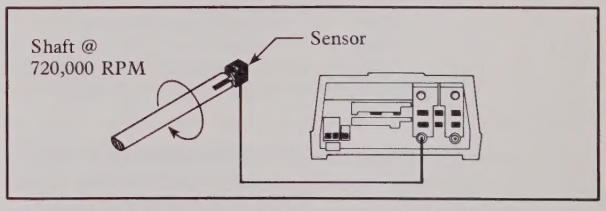


Figure 32.

The sensor output will be 720,000 pulses/min, dividing this by 60 = 12,000 pulses/sec. If you put 12 kHz input to the counter in the CPMx100A mode, it will display 7200 (not 720,000). This is because this mode is set up to work in conjunction with the 100 tooth wheel in Figure 31.

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